Radiation Data and Reports

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'ĭ
10^{-2}	centi	c	sĕn'tĭ
10^{-3}	milli	m	mĭl'ĭ
10^{-6}	micro	μ	mī'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.206 lb.
km²	square kilometer(s)	
kVp	kilovolt peak	
m³	cubic meter(s)	
mA	milliampere(s)	
mCi/mi²	millicuries per square mile	0.386 nCi/m² (mCi/km²)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi²	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m²	nanocuries per square meter	2.59 mCi/mi²
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

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U.S. ENVIRONMENTAL PROTECTION AGENCY

William D. Ruckelshaus, Administrator

Reports

Calculations of Environmental Radiation Exposures and Population Doses Due to Effluents from a Nuclear Fuel Reprocessing Plant

James A. Martin, Jr.[1]

Effluent and environmental data pertinent to the Nuclear Fuel Services nuclear fuel reprocessing plant in West Valley, N. Y., were analyzed to determine doses to sample populations. Individual doses to the maximally exposed population group were considered. Population doses (man-rems) from air, fish, deer, and water pathways were calculated. The most significant radionuclides contributing to doses were tritium, krypton-85, strontium-90, cesium-134 and cesium-137. It was concluded that the impact of this facility upon humans was well below applicable guides in 1971.

Within the nuclear fuel cycle, the fuel reprocessing plant offers a great potential for significant impact on the environment. At fuel reprocessing plants, partially spent uranium and plutonium are recovered as valuable natural and national assets from the fuel assemblies discharged by nuclear power plants. It is at this stage in the fuel cycle that the bulk of long-lived fission products built up in the nuclear fuel are released from the fuel cladding. Although only small fractions of most nuclides are released to the offsite environment, the inventory itself is so large that small fractional releases may lead to a measurable environmental impact.

This report analyzes the effluent and environmental data pertaining to the Nuclear Fuel Services Fuel Reprocessing Plant (NFS) in West Valley, N. Y., to obtain a measure of the impact of the plant effluents upon humans. The impact is assessed in terms of the dose delivered to humans subjected to the radiation released to the environment by the NFS plant. Doses to sample populations during 1971 were calculated. The calculational approach taken herein amplifies upon that used in an earlier review (*1*) in that local and worldwide population doses (man-rem) are considered as well as individual doses (rems).

Doses were calculated using effluent data reported by NFS in their quarterly operating reports and semiannual environmental reports (*2-4*) and were supplemented by information from a number of other sources. The significant exposure pathways considered include air, milk, water, fish and game. Both submersion and inhalation doses were considered. The ingestion pathway was analyzed by assuming reasonable consumption levels for a standard man. The doses delivered by the various radionuclides released from the plant were calculated using techniques recommended by the International Commission on Radiological Protection (ICRP). The resultant doses are compared to the guidance promulgated by the ICRP and the U.S. Atomic Energy Commission (AEC). To the extent possible in the calculations, care was taken to subtract natural background and fallout activities; thus, all doses reported herein are those reasonably attributable to the NFS plant alone.

In order, the following sections present a summary of the results of the analysis, a de-

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scription of plant operations, individual doses via the air and water effluent exposure vectors, and population doses along these vectors. Recommendations based upon the analyses, references, and bibliography complete this report.

Summary of results

Individual doses were calculated for the average of the maximally exposed population groups in the immediate vicinity of the Nuclear Fuel Services facility. Ingestion population doses (man-rem) were calculated for the local maximally exposed population group, namely, sportsmen consuming fish and game having contact with the creek system carrying liquid plant effluents. Local (1 to 50-mile radius) and worldwide krypton-85 submersion population doses were also calculated. A summary of the NFS plant operations and doses to population groups for 1971 is presented in table 1. It is noted, however, that future plant capacity at NFS will increase by a factor of 15 over 1971 throughput. Also, most fuel reprocessed at NFS to date had been cooled for much longer than the 150 days minimum required by the NFS license. Further, NFS plans to add a fuel fabrication plant nearby. Thus, surveillance of the radiation effluents from these facilities should be maintained.

NFS plant operations

Nuclear Fuel Services began reprocessing spent nuclear fuel in April 1966 under AEC License No. CSF-1 (AEC Docket No. 50-201) and operated continually throughout 1971. The basic purpose of the plant is to recover uranium and plutonium from spent fuel elements from nuclear power plants. The terms of the NFS license essentially allow a maximum of 1 tonne of fuel per day to be processed; the plant capacity is about 300 tonnes per year. About 30 percent of a power plant's fuel inventory, or about 30 tonnes of fuel from a 1000-megawatt (electric) plant, is removed annually for reprocessing. The composition of spent fuel varies with exposure, burnup, reactor design, operating characteristics, fuel location in the core and fuel cooling time, but typical values of some significant parameters are given in table 2 (*5*).

All fuel is cooled at least 150 days before processing. Upon receipt at NFS, fuel containers are unloaded under water and the fuel is transferred to a 28-foot deep storage pool. Within this pool, the elements can be visually inspected, and the pool water is surveyed to detect radioactivity which may leak from damaged fuel elements.

Table 1. Summary of significant data and calculations

NFS Plant operations—1971:

Fuel reprocessed: 68.8 tonnes
794 gigawatt-days exposure
11,500 megawatt-days/tonne burnup

Major stack effluents: 2.21×10^5 Ci krypton-85
1,070 Ci tritium

Major water effluents: 4×10^3 Ci tritium
6.6 Ci strontium-90
0.21 Ci iodine-129
77 Ci gross beta, other than tritium
0.06 Ci gross alpha

Individual doses (first year):

Average whole body doses for an individual in the maximally exposed group:

Tritium transpiration and inhalation	0.02 mrem
Krypton-85 air submersion	.01
Deer meat ingestion	.5
Fish meat ingestion	2.5
Creek bank occupancy	2.8
Total	5.83 mrem
ICRP recommended limit	170 mrem

Whole body population doses (first year):

Tritium in drinking water [a]	16 man-rem
Krypton-85 submersion (0–50 miles)	1
Deer meat ingestion	5
Fish meat ingestion	1
Total	23 man-rem
Krypton-85 submersion (worldwide)	6 man-rem (first year)
	100 man-rem (total dose commitment)

[a] Includes estimated populations served by municipal intakes in Lake Erie, Lake Ontario and along the St. Lawrence River to Cornwall, Ontario, Canada.

Table 2. Significant radionuclide inventories of typical[a] light water reactor fuels at 33,000 MWd/tonne uranium, 30 MW/tonne uranium, 180 days cooling[b]

Fuel composition:

Uranium—averaging 0.85 weight percent uranium-235
Plutonium—9 to 12 kg Pu/tonne uranium

Radionuclide inventory:

Gross beta and gamma fission products—4.2×10^6 Ci/tonne uranium.

Strontium-89	65,000 Ci/tonne ur nium
Strontium-90	76,600 Ci/tonne uranium
Krypton-85	11,000 Ci/tonne uranium
Tritium	690 Ci/tonne uranium
Iodine-131	0.165 Ci/tonne uranium
Iodine-129	0.037 Ci/tonne uranium
Ruthenium-rhodium-106	388,000 Ci/tonne uranium
Cesium-134	209,000 Ci/tonne uranium
Cesium-137	107,000 Ci/tonne uranium
Cobalt-60	6,050 Ci/tonne uranium
Ruthenium-103	52,200 Ci/tonne uranium

[a] Actual composition varies with burnup, reactor design, core placement, operating characteristics and cooling time.
[b] Personal communication, Nuclear Fuel Services, Inc. Data calculated using ORIGEN code.

When required for reprocessing, the fuel assemblies are moved into a hot cell where the end-fitting hardware is removed and the fuel elements (rods) are mechanically sheared into small pieces. It is at this point that the volatile fission products begin to be released to the off-gas treatment systems and thence to the environment. The pieces are collected in metal baskets and loaded into large vats called dissolvers.

Dissolution of the fuel begins when nitric acid is injected into the loaded dissolvers. One metric ton of uranium (tonne U) is dissolved to liquid form in about 4 hours. Gases trapped in the fuel, such as krypton-85, are released during the dissolution. The exhaust from the dissolvers eventually passes through two HEPA filters in tandem (99.97 percent rated removal efficiency each for particles greater than 0.3 μm) before being released from the 60-meter stack.

High-level liquids (ca. 400 gallons/tonne U) are stored in underground vaults onsite in tanks with filter vents connected to the stack. Low-level liquids are released to the offsite environment after treatment, storage and delay in three large lagoons (5 million gallons total capacity). The rate of discharge from the lagoons is controlled so as to maintain a gross beta concentration in the local offsite creek (Cattaraugus Creek) below 150 pCi/liter. The insoluble metal cladding materials are monitored to establish completeness of dissolution of fuel and are buried in an AEC-licensed onsite solid waste storage area. New York State licenses a low-level waste burial site at the facility.

The dissolver solution undergoes solvent extraction which separates the fission products from the contained uranium and plutonium, and also separates uranium and plutonium from each other. Purification (from trace fission products) occurs before the final products, uranyl nitrate and plutonium nitrate, are recovered and stored in licensed shipping containers.

References *4-6* contain more detailed information regarding the plant fuel reprocessing cycle.

In May 1971, NFS began operating a one million dollar, low-level, liquid effluent cleanup plant to reduce the concentrations of strontium and cesium radionuclides in the low-level liquid waste effluent to below MPC_w at the point of release from the lagoons. As of spring 1972, the plant was operating under an interim AEC technical specification on liquid effluents. The AEC has set an eventual goal that all radionuclides in liquid effluents, including tritium, are to be below MPC_w at the plant holdup lagoon outfall before dilution in the onsite Buttermilk Creek (*7*). The precipitation and ion exchange plant reduced cesium radionuclides to below this specification, but not strontium (*3*); these, plus ruthenium, were found to be the most significant radionuclides in the low-level liquid waste effluent.

NFS ceased reprocessing in December 1971 and cleanup and decontamination procedures began in preparation for modifications to increase capacity (throughput). When again online, the plant licensed capacity will essentially triple to 3 tonne uranium/day.

In addition to the fuel reprocessing plant, NFS plans to build a fuel fabrication facility (*7,8*) on the 3,345-acre Western New York Nuclear Service Center (WNYNSC) owned by the New York Atomic and Space Development Authority. The fuel reprocessing site occupies

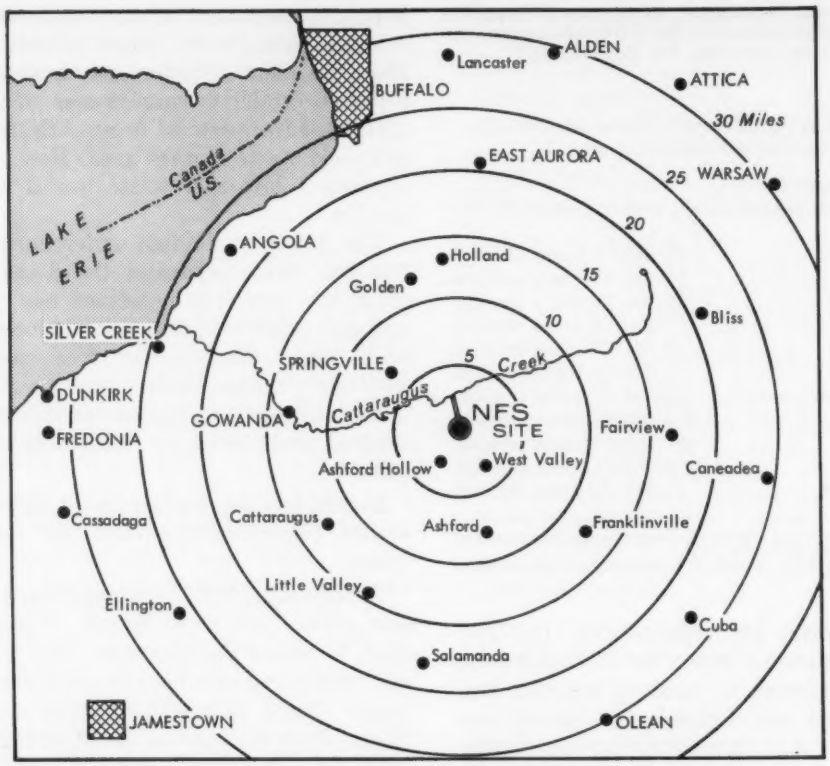

Figure 1. Location of the Western New York Nuclear Service Center including the Nuclear Fuels Services site

180 acres of the WNYNSC (figure 1). The WNYNSC is shaped like a long-necked vase, the neck bounding Buttermilk Creek to its confluence with Cattaraugus Creek. Cattaraugus Creek flows 36 creek miles to Lake Erie. The creeks offer an average dilution factor of 1 to 2×10^3 to the lagoon outfall. These creeks and the stack are the primary vectors routing radionuclides to the offsite environment.

Dose from airborne activity

Source terms

Airborne radioactivity associated with the NFS facility arises principally at the cutting and dissolution stage. Tritium, krypton-85, and iodine-129 were potentially the most radiologically significant radioisotopes released from the stack during 1971. There are no facilities at NFS for collecting and storing krypton-85. The krypton-85 effluent data reported by NFS (table 3) (*2,3*) correlate very well with the assumption that 100 percent of the fuel's krypton-85 inventory is released from the stack.

Establishing credible source terms for tritium and iodine-129 is more complicated, the most serious uncertainty being that for iodine-129. Although a silver nitrate reactor was installed at NFS for iodine removal before stack release, it has not generally been used because of the long cooling time and the consequent decay of iodine-131 to insignificant levels. A mercurous-mercuric nitrate scrubber has generally been used. Some measurements indicate that at least 5 percent and possibly as much as 20 percent (*9,10*) of the radioiodine inventory is released from the stack.

Table 3. Source terms for NFS 1971 stack releases
(Curies released)

1971 quarter	^{85}Kr [a]	^{3}H [b]	^{129}I [c]	^{89}Sr	^{90}Sr	^{106}Ru	^{134}Cs	^{137}Cs
January-March	56,000	0.24	10×10^{-4}	0.2×10^{-4}	1×10^{-4}	6×10^{-4}	1×10^{-4}	4×10^{-4}
April-June	56,000	35	15×10^{-4}	2.4×10^{-4}	1.6×10^{-4}	3×10^{-4}	4×10^{-4}	2×10^{-4}
July-September	86,500	109	0.2×10^{-4}	—	0.3×10^{-4}	1×10^{-4}	0.2×10^{-4}	1×10^{-4}
October-December	22,300	930	1×10^{-4}	0.1×10^{-4}	0.5×10^{-4}	3×10^{-4}	0.7×10^{-4}	2×10^{-4}
1971 totals (Ci)	220,800	1,070	2.6×10^{-3}	2.7×10^{-4}	3.4×10^{-4}	13×10^{-4}	6×10^{-4}	9×10^{-4}

[a] From NFS 1971 environmental reports.
[b] 1.33 times for tritiated stack vapor reported in NFS 1971 environmental reports. See text for explanation of factor.
[c] From NFS 1971 environmental reports, ignoring possible gaseous releases not detected.

Semiannual NFS environmental reports for 1971 (*2,3*) contain iodine-129 data obtained from stack samplers, and such data are used herein. However, the possibility of much greater iodine-129 releases cannot be ignored. A complication to obtaining a credible source release term for iodine is the indication that gaseous organic iodides are formed in uncertain quantities during the dissolution process (e.g. methyl iodide and hypoiodous acid) (*10*). The NFS stack monitor data (table 3) accounted for only 0.3 percent of the iodine-129 inventory in the fuel processed at NFS in 1971 (the inventory being calculated using the data in tables 1 and 2). Yet very recently, low but detectable levels of iodine-129 have been found in local milk obtained from cows on winter feed (*11,21*); the concentrations fell sharply after the cows were placed on pasture feed in the spring of 1972. In 1971, the iodine-129 in the liquid effluent amounted to about 20 percent of the iodine-129 inventory in the fuel processed during that year. Some of this effluent was undoubtedly associated with earlier reprocessing.

Tritium stack release source terms are also somewhat in doubt, but to a lesser extent than for iodine-129. The NFS environmental reports for 1971 contain measured aqueous tritium activity releases obtained from Drierite water vapor traps installed in mid-1970 in the stack monitors. A series of measurements made at NFS by the Environmental Protection Agency (*13,14*) indicate that the total tritium released is 1.33 times the tritiated water vapor released. Thus, it was assumed that the total tritium released was 1.33 times the tritiated water vapor release measured and reported by NFS. This total amounted to 6 percent of the tritium inventory calculated using the data in tables 1 and 2 (some tritium is lost at the reactor, however).

Other radionuclides released from the stack, as reported by NFS (*2,3*) are listed in table 3. The quantities released were far less than for krypton-85 and tritium. Other radionuclides released in even less significant quantities are listed in reference 9.

Submersion and inhalation doses

Submersion and inhalation doses were calculated using ICRP (*15*) and FRC (*16*) methodology and exposure data reported by NFS. The krypton-85 exposures listed in table 4 for 16 compass directions were calculated by NFS using measured release rates and the long term sector averaged exposure equation (*17*):

$$\Psi = \left(\frac{2}{\pi}\right)^{1/2} \frac{f\,\Delta Q'\Delta t \exp -h^2/2\sigma_z^2}{\bar{u}\sigma_z\ 2\pi r/n} \qquad \ldots (1)$$

where: f = fractional wind frequency in a sector,
r = distance from the stack in meters,
h = effective stack height in meters,
n = number of sectors,
$2\pi r/n$ = sector width at distance r in meters,
σ_z = standard deviation of the vertical distribution of an assumed gaussian cloud, in meters,
$\bar{u}$ = average wind speed in the sector in m/s,
$\Delta Q'$ = average curies of activity released per second during time interval,

Δt = time interval of radioactive release in s, and

Ψ = ground level exposure of radioactivity in Ci-s/m³.

The exponential term in equation 1 rapidly approaches unity offsite and Ψ varies inversely with the product $r\sigma_z$ thereafter. σ_z is a monotonically increasing function of distance, values for which are also functions of stability class; higher values generally prevail for unstable wind conditions. n normally equals 16. An extensive discussion of these and other meteorological parameters is presented in references *17* and *18*.

The NFS meteorological data were obtained using instruments located onsite, principally at the top of the stack. Although NFS provides a yearly average joint frequency distribution (wind frequency, stability class and wind speed in 16 compass directions), the krypton-85 exposure data in table 4 were used in this analysis. These data were deemed most applicable since stack releases occurred over only a small fraction of the year and a wind rose corresponding only to the release periods should be used to calculate doses.

Expressed in exposure units, the ICRP recommended maximum permissible concentration in air (MPC_a) of krypton-85 for continuous occupancy by a nonoccupational individual is 3×10^{-7} Ci/m³ $\times$ 3.16×10^{7} s = 9.5 Ci-s/m³. The ICRP yearly whole (total) body submersion dose corresponding to this exposure is 500 mrem/year (assuming continuous, uniform exposure and a semi-infinite air cloud). Using these assumptions, the maximum whole body dose at 3 km due to krypton-85 submersion occurred in the west sector (table 4) and was 2.5 millirem for the year. The skin dose at this point from tritium submersion amounted to 1.1 microrem for the year. For the remaining radionuclides listed in table 3, submersion whole body doses were less than 10 percent of the tritium dose.

A complete yearly average joint frequency distribution corresponding to the exposure data in table 4 was not available for this study. Table 5 presents the meteorological summary that was available (*19*). The data in this table indicate that winds blowing to the west were predominantly of class B stability. With class B stability, the maximum site boundary dose would be higher than the 3 km dose by a factor of about seven. However, considering the pristine state of the immediate offsite environs of the NFS facility, the occupancy factor for the boundary locations most likely would be considerably less than 1/7, leading to a lower yearly dose than the 3 km west sector dose. Conversely, a small community does exist 3 km to the west, and assuming continuous occupancy for some of these individuals is reasonable.

Table 4. Krypton-85 exposure at 3,000 meters from plant stack, 1971[a]

Sector	1971 total (Ci-s/m²)
North	0.0104
North northwest	.0213
Northwest	.0026
West northwest	.0176
West	.0482
West southwest	.0105
Southwest	.0146
South southwest	.0305
South	.0358
South southeast	.0000
Southeast	.0420
East southeast	.0120
East	.0123
East northeast	.0007
Northeast	.0003
North northeast	.0056

[a] From NFS Environmental Report No. 11 (*3*).

Table 5. NFS 1971 annual average meteorological data

Fraction of occurance	Pasquill stability class [a]	Average wind speed at top of stack (m/s)
0.74	B	4.28
.20	D	3.49
.06	E	2.23

[a] 1. Stability based upon average wind variance.
2. Cross valley winds generally quite turbulent, Class B tending toward Class A.
3. Axial valley winds tend toward D.
4. Pasquill stability classes are described in references *17* and *18*.

Krypton-85 whole body dose

A discussion of the term "whole body dose" as used above is warranted. The ICRP "whole body dose" is predominantly a surface (skin) dose for primarily beta emitters such as krypton-85. The whole body (gonad) dose of the "maximum" krypton-85 exposed group described above was far less than the skin dose. The following analysis was used to bound the gonad dose. An estimate of the krypton-85-induced gonad dose was obtained using the semi-infinite cloud dose model (*20*). For the gamma component:

$$\dot{D} = 0.25\ \overline{E}_{\gamma}\chi(\text{rad/s}) \qquad \ldots (2)$$

where $\overline{E}_{\gamma}$ is the average gamma energy per disintegration in MeV and χ is the air concentration in Ci/m³. Taking $\overline{E}_{\gamma}$ as the product of the krypton-85 gamma energy ($\overline{E}_{\gamma} = 0.513$ MeV) and gamma branching ratio (0.00413), the annual whole body gamma dose from krypton-85 is 5 mrem/year for continuous exposure to a semi-infinite gas cloud of 300 nCi/m³ (non-occupational MPC_a) krypton-85 concentration. Thus, the gonad dose due to krypton-85 gamma emissions only is approximately 1 percent of the dose calculated using ICRP II methodology.

Estimates of the beta component of the gonad dose are tissue-depth dependent because of the attenuation of the beta particles and the bremsstrahlung produced; a typical value at a depth of 7 mg/cm² tissue, i.e., below the dead layer of skin, is 3 percent of the ICRP whole body dose (*21*). The 3 km, west sector genetically significant dose from NFS krypton-85 emissions in 1971 is thus bounded by 0.025 and 0.075 millirem, i.e., in the same range as the ICRP model tritium submersion dose. Because of the semi-infinite cloud model used, even these low calculated exposures are overestimates of the genetically significant submersion doses.

Inhalation doses

Inhalation doses at 3 km in the west sector were calculated for the particulates listed in table 3. Doses were calculated using the equation:

$$D_i = \Psi_{Kr}\frac{Q_i}{Q_{Kr}}\left(\frac{AD}{MPC_a}\right)_i \qquad \ldots (3)$$

where: D_i = the dose to the critical organ associated with the i^{th} radionuclide listed in table 3,

Q_{Kr} = the year's release of krypton-85 in curies,

Q_i = the year's release of the i^{th} radionuclide in curies,

$\left(\frac{AD}{MPC_a}\right)_i$ = the ratio of the ICRP annual dose (AD) in rem/year to the associated MPC_a of the i^{th} radionuclide in Ci-s/m³, and

Ψ_{Kr} = the krypton exposure in table 4.

For each radionuclide, the inhalation dose was calculated as the dose to the organ for which the corresponding form of the radionuclide, soluble or insoluble, has the lowest MPC_a. The resultant inhalation doses were all very small and are listed in table 6.

Table 6. Inhalation doses
(West sector-3 km)

Isotope (form)	Critical organ	1971 dose (mrem/year)
Iodine-129 (Soluble)	Thyroid	9×10^{-4}
Strontium-89 (Soluble)	Bone	6×10^{-6}
Strontium-90 (Soluble)	Bone	7×10^{-4}
Ruthenium-106 (Insoluble)	Lung	7×10^{-5}
Cesium-134 (Insoluble)	Lung	2×10^{-5}
Cesium-137 (Insoluble)	Lung	2×10^{-5}
Tritium[a]	Whole body	2×10^{-3}

[a] Includes transpiration dose.

Iodine-129 in milk

Recent reports (*11,12*) have shown that milk taken from cows feeding on local stored feed around NFS contained measurable quantities of of iodine-129. Concentrations ranged from 2 pCi/liter to 0.05 pCi/liter at distances of 1.5 to 7 miles from the plant. The measured concentrations decreased monotonically with distance.

It has not been possible to establish credible assumptions for a dose calculation for the milk

pathway. Although some milk is processed locally, most forms part of a large milk pool processed in the Buffalo, N.Y., area; some is processed in the New York City area. Because of this pooling with uncontaminated milk, the average concentration of iodine-129 in milk and milk products would be a small fraction of the observed values.

Several considerations influence a dose calculation, all of which are very uncertain. The number of persons drinking unpooled milk from local farms, if any, is unknown. The dose calculation would be related to the time intervals between depositions on individual pastures and weathering factors which remove it from foliage; these data are also unknown. Also, the time between deposition and feed storage is unknown. The lack of these and other factors precludes a credible dose calculation at this time.

Because of these significant findings, the New York State Department of Environmental Conservation will continue to evaluate the iodine-129 concentrations in milk even though the NFS plant is not processing fuel at the present time. Further, NFS is presently making plant modifications to assure significant in-plant iodine decontamination before effluents are released to the environment. These efforts should result in the reduction of iodine-129 impact to even lower levels.

Population dose due to milk ingestion is discussed below.

Water vectors

Ingestion doses

The Buttermilk-Cattaraugus Creek system constitutes a significant radionuclide vector to a *select* population in the vicinity of NFS. Various pathways include direct shine from the creek and radioisotopes on the creek banks, fish taken from the creek, and game animals whose prime water source is the creek. According to several reports (*1,5,6,22,23*) there are no potable water supplies served by the creek system; further, samples of crops partially irrigated with Cattaraugus Creek water show no crop uptake of NFS-associated radionuclides when compared to crops in other parts of New York State (*5,22*). Thus, the main water exposure vector to people is restricted to the immediate vicinity of the creek system and is of importance only to those few persons in intimate contact with it. Such individuals constitute the maximally exposed group.

The true impact of the creek system upon the population can be derived only from local demographic data which are presently insufficient for an accurate dose calculation. In recognition of this, and based partially upon the recommendations of Shleien (*1*), the EPA, with the cooperation of the New York State Department of Environmental Conservation, conducted an extensive survey of inhabitants (predominantly sportsmen) of the creek system from NFS to Lake Erie in 1971. Unfortunately, little of these data is available at this time.

Lacking complete demographic data and an officially accepted description of a "suitable" individual, a calculation of ingestion dose was made using reasonable consumption levels. The consumption levels assumed are listed in table 7. They are taken to be representative of the average of the maximally exposed population group.

Table 7. Estimated average yearly dietary intakes and exposure times for maximally exposed group

Media	Consumption or exposure time
Deer	4.8 kg
Fish	4.3 kg
Drinking water	0 liters
Air submersion	8,736 h
Creek bank occupancy	100 h

It is unlikely that any single individual will be found to have exactly the dietary intake and exposure time described in table 7. Preliminary demographic data clearly separate hunters and fishermen in the NFS area. In essence, those who fish in Cattaraugus Creek do not hunt and those who hunt would not fish in Cattaraugus Creek. On the other hand, there are both hunters and fishermen in the area and the data described in table 7 are an attempt to form a composite. For several reasons, the com-

posite ignores intakes from other game animals, e.g., rabbits. There exist no small game consumption data for the area, and data on some small animals that inhabit the creek system (rabbits and raccoons) show no significant NFS-associated radionuclides (*3,23*) other than iodine-129 in thyroids which are not considered pathways to humans.

Deer meat consumption is based upon a preliminary analysis of the EPA demographic data (*24*); the 4.8-kg consumption listed in table 7 is 1/10 of the maximum found in the study and represents the median consumption; the mean consumption was about a factor of two lower. The assumed fish flesh consumption is one quarter of the 50 grams per day consumption reported (*25*) for commercial fishermen. The creek bank occupancy factor is based upon 1 hour per day occupancy of the bank during the summer months.

Average concentrations of radionuclides (*2,3,22*) in the foods in table 7 are listed in table 8. To the extent possible, doses were calculated only for NFS-associated vectors; fallout and natural background radiation were not included. Table 9 lists the dose conversion factors used to relate ingested activities to yearly dose (*1,15,16,26*). Table 10 lists the yearly doses to critical organs resulting from the ingested isotopes; this table also shows the equation used to calculate the yearly doses. The predominant ingestion pathway is fish taken from the creek.

Table 8. Average concentration of radionuclides in deer and fish flesh taken in the vicinity of NFS

Sampling vector	Radionuclide concentration (pCi/kg)				
	Cesium-137	Cesium-134	Cobalt-60	Strontium-90	Tritium
Deer [a]	945	252	49	15	—
Fish flesh [b]	3,500	1,100	—	470	28,000

[a] 14 samples from "1970 Annual Report of Environmental Radiation in New York State," and one sample from NFS Environmental Report No. 11 (*3*) 1971. Twelve deer taken onsite in 1970, two within the exclusion area.

[b] From NFS Environmental Reports Nos. 10 and 11 (*2,3*) for 1971. 17 suckers, 1 trout, all 6-inches long. Tritium levels assumed equal to Cattaraugus Creek tritium concentration near NFS; assumed reconcentration factor = 1. Concentration near Lake Erie could be lower by at least a factor of 5.

Table 9. Ingestion dose conversion factors [a]

Radionuclide	Critical organ	Dose conversion factor (rem/year per pCi intake)
Strontium-90	Bone	0.6×10^{-6}
Cesium-137	Whole body	$.06 \times 10^{-6}$
Cesium-134	Whole body	$.08 \times 10^{-6}$
Cobalt-60	G I tract	$.04 \times 10^{-6}$
Tritium	Whole body	$.13 \times 10^{-9}$

[a] Taken from Shleien (*1*).

Direct dose

The remaining significant water vector to be discussed is the direct dose from the radioisotopes in the creek. For the most part, these are bottom sediment radionuclides and are of significance only after having settled out and become exposed on the creek banks after periods of turbulent flow. Hot spots on the creek bank have been found annually during the late summer, the highest recorded exposure rate being 132 microroentgens per hour (*22,23*). These hot spots dissipate quickly and it is difficult to derive an average dose rate from them. An estimate of the average was made using the ratio of the average dose rate recorded at the NFS perimeter monitor (on Cattaraugus Creek) to the maximum dose rate recorded there for the year, this ratio being 0.22 (*2,3*). An upper estimate of the average exposure rate on the Cattaraugus Creek bank, then, is $0.22 \times 132 = 28$ microroentgens per hour. Using a quality factor of one, the creek shine dose for 100 hours per year occupancy is 2.8 millirem per year (whole body).

Population doses

Population dose (D_p) is the product of the population and the arithmetic average dose absorbed by that population. D_p has units of man-rem. Mathematically:

$$D_p = \sum_{i=1}^{N} \sum_{j=1}^{N} P_j D_i \delta_{ij} = N \bar{D} \begin{cases} \delta_{ij}{}^{=1 \text{ for } i=j} \\ \\ \delta_{ij=0 \text{ for } i \neq j} \end{cases} \quad \ldots \quad (4)$$

where: N = the total population involved,
D_i = the dose absorbed by individual P_j in that population, and
δ_{ij} = the Kronecker delta, defined as shown above.

Figure 2. Population distribution and 1971 population skin doses by sector segment between 1 and 80 kilometers

Submersion population dose from the air pathway and ingestion population doses from the fish, deer, and water pathways were calculated. To put the matter into perspective, the submersion population dose due to natural background radiation for the two and one-half million people within 50 miles of the NFS plant is about 275,000 man-rem per year. All population doses due to NFS effluents were calculated to be many orders of magnitude lower than this.

Fifty-mile radius submersion population dose

The population dose from the airborne pathway was calculated for the case of submersion in a krypton-85 cloud. The population considered was that within a 50-mile radius of the NFS plant. The area around the plant was divided into 160 sector segments and populations within these sector segments were determined according to 1970 census figures as reported by NFS (*7,27*). The populations of small towns in the immediate vicinity of the plant were obtained from the Cattaraugus County Planning Department. The onsite population (zero to 1-mile radius) was not included in the calculation. The population distribution by sector segment is shown in figures 2 and 4.

The submersion population dose was calculated using the following equation:

$$D_p = \sum_{j=1}^{160} D_{pj} = 0.0526 \sum_{j=1}^{160} P_j \Psi_j \quad \ldots (5)$$

where: P_j = population in j^{th} sector segment,
Ψ_j = ground level exposure of krypton-85 in j^{th} sector segment in Ci-s/m^3,
D_{pj} = submersion population dose in in j^{th} sector segment in man-rem/year, and
0.0526 = ratio of 0.5 rem/year to 9.5 Ci-s/m^3, i.e., a dose conversion factor derived from ICRP recommendations (*15*).

Ψ_j's for each sector segment were calculated from the data in tables 4 and 5, and figure 3, using equation 1. Table 4 gives the angular variation of Ψ at a radius of 3 kilometers. For any angle, the variation in Ψ with distance depends only upon distance and stability class. Accounting for distance variations is straight forward. The available information regarding stability classes is given in table 5. Stability classes for the 16 compass directions used in the calculation are shown in figure 2. The assumed stability classes roughly approximated the yearly average of the local meteorology in that cross-valley winds were assumed to be of class B stability with a 75 percent occurrence and axial valley winds were assumed to be of class D stability with a 25 percent occurrence.

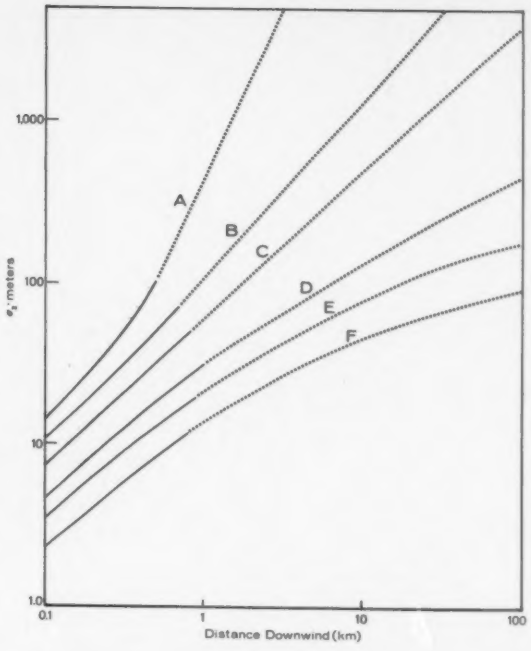

Figure 3. Vertical dispersion coefficient as a function of downwind distance from the source (Taken from EPA, Office of Air Programs Publ. AP-26) Letters A to F denote Pasquill stability classes; dashed portions of curves are less certain than solid portion.

Having defined the stability classes, the associated σ_z's at the midpoints of the sector segments were obtained from published data and are reproduced in figure 3 (*18*).

It was recognized that this calculational procedure left much to be desired. However, it was the best available technique and reflects the current state of the art. Calculations based upon equation 1 are to be considered "best estimates" only (*18*). Factor of two discrepancies between experiment and this theory are commonly found within a few miles of a source (*17,18*). Factor of 10 discrepancies have been found at greater distances (*17*).

An unpublished computer program, EXDOSE, was used to perform the calculations of equation 5. For the 12 sectors for which class B stability was assumed, a 1,300 meter capping layer was assumed, thereby limiting σ_z to a

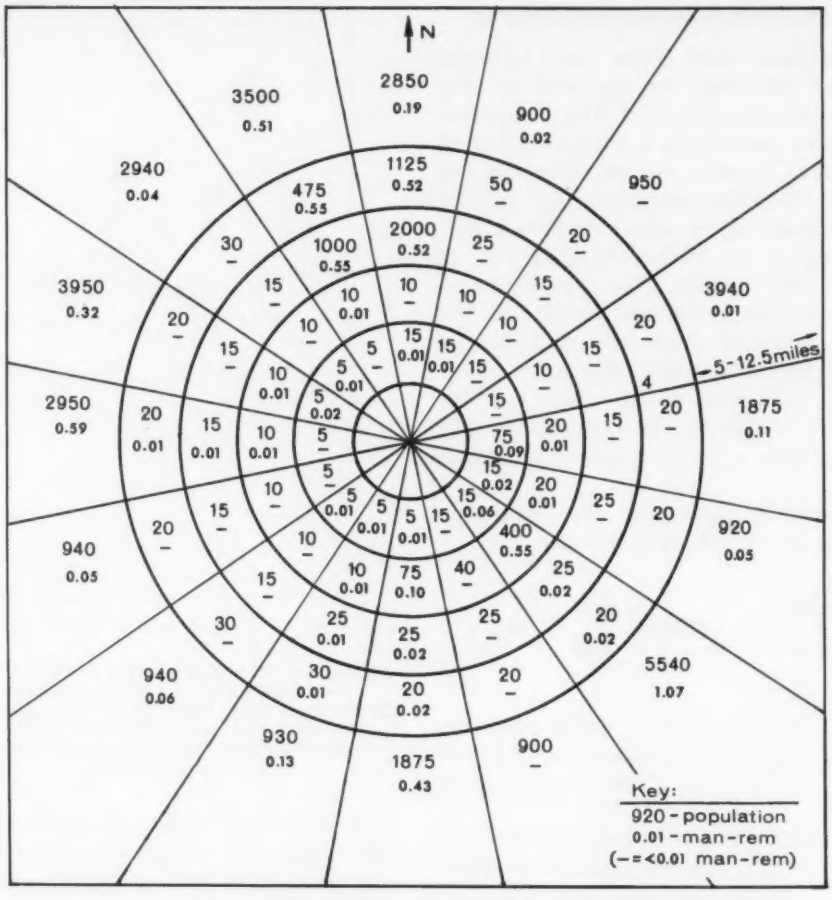

Figure 4. Population distribution and 1971 population doses by sector-segments between 1 and 12.5 miles (1.6 to 20 kilometers)

maximum of 1,000 meters. This corresponds to the yearly average height of the capping layer for upper New York State (*28*). The population dose from krypton-85 submersion was calculated to be 46 man-rems (skin) due to NFS releases in 1971.

As noted previously, this submersion population dose is predominately a skin dose. The genetically significant (gonad) population dose averaged 2 percent of the skin population dose, or 1 man-rem. Figure 4 presents the in-close sector segment populations and population doses, and figure 5 illustrates the isodose contours.

Gross worldwide submersion population doses

Krypton-85 is one of the few long-lived radionuclides dispersed in significant quantities worldwide from the nuclear fuel cycle. A gross estimate of the worldwide population dose from krypton-85 submersion was obtained using a very simple atmospheric model. The equilibrium concentration of krypton-85 in the world due to NFS releases in 1971 is 2.21×10^5

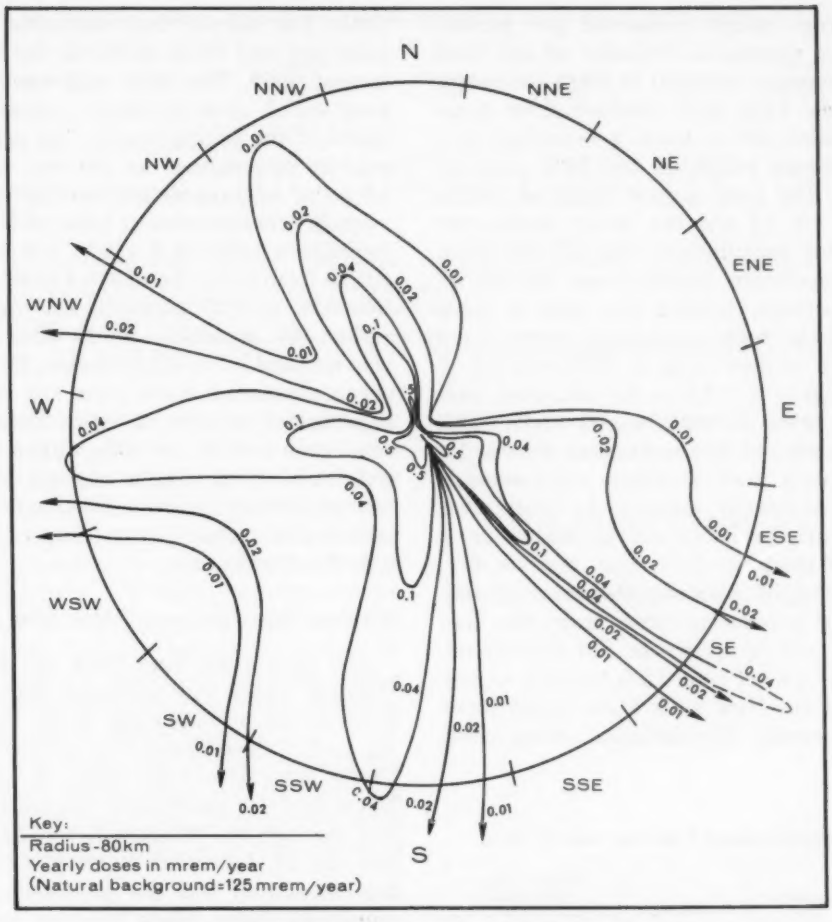

Figure 5. Isodose contours for upper New York State from NFS krypton-85 releases in 1971
(Onsite meteorology during periods of release was used to propogate the krypton-85 throughout the region)

Ci/7.6 $\times$ 10^{18}m^3 = 2.9 $\times$ 10^{-14} Ci/m^3. At this concentration the skin dose (submersion) is 5 $\times$ 10^{-8} rem/year, assuming a uniform volumetric concentration. Since it is more reasonable to assume mixing to a constant mixing ratio (*29*), this dose should be about doubled to 10^{-7} rem/year. The total population in the world is about 3 $\times$ 10^9 persons, resulting in a population dose of 300 man-rem/year (skin). The gonad population dose is about 2 percent of this or 6 man-rem/year. Knox and Peterson (*29*) estimate the dose commitment to be 16.1 times this yearly population dose, or about 100 man-rem (gonad) for a static population. The natural background induced population dose is about 4 $\times$ 10^8 man-rem/year.

Population dose from ingestion of game

Population doses from the deer and fish ingestion pathways were obtained using an estimated ratio of the total yearly catch weight

to the average weight consumed per person. This gives a reasonable estimate of the total number of persons involved in these pathways. Data for deer kills were obtained from questionnaires filled out by hunters reporting kills within a 20-mile radius of the NFS plant in 1970. (*24*). The total annual reported intake was 5.5×10^4 kg and the mean annual per capita venison consumption was 2.7 kg. Thus, the total population involved was 55,000/2.7 = 20,000 persons. Scaling the data in table 10, the whole body population dose from the ingestion of deer meat in 1971 was $0.4 \times 10^{-3} \times 20{,}000 \times 2.7/4.8 = 4.5$ man-rem, predominantly from cesium-134 and cesium-137. Other organ population doses appear in table 11. Since these data were calculated using average concentrations heavily weighted by onsite deer kills, they are probably overestimates by a considerable margin.

The demographic data required to adequately estimate the population dose from the fish pathway are not yet available. For this report, the results of a brief creel (fish basket) survey conducted by the New York State Department of Environmental Conservation were used (*30*). The survey was conducted over three weekdays and three weekends during July and August 1969. The daily and weekly averages were scaled up to 33 weeks, approximately the length of the fishing season. The pertinent data may be summarized as follows: 4,752 fish of 0.5 pound average weight were taken. Using the average concentration of 3,500 pCi/kg and dose conversion factor of 6×10^{-8} rem/year per pCi intake from tables 8 and 9, a whole body population dose of 0.23 man-rem was calculated for cesium-137 ingestion. As in other cases, this was rounded off to 0.2 man-rem. This and other organ population doses from fish ingestion are summarized in table 11. Since the average concentration used in the calculations was heavily weighted by fish caught between NFS and the nearby Springville Dam, these man-rem calculations also probably overestimate the dose by a considerable margin.

Table 10. Ingestion doses from deer and fish flesh

Radionuclide	Ingestion dose [a] (mrem/year)	Critical organ	Pathway dose (mrem/year)	
			Fish	Deer
Strontium-90	1.3	Bone	1.2	0.05
Cesium-134	.5	Whole body	.4	.10
Cesium-137	1.2	Whole body	.9	.3
Cobalt-60	.01	G I tract	ND	.01
Tritium	.015	Whole body	0.015	ND

[a] Dose = consumption (kg) × concentration (pCi/kg) × dose conversion factor $\frac{(\text{mrem/year})}{\text{pCi}}$.
ND, nondetectable.

Table 11. Ingestion population doses

Radionuclide	Critical organ	Population dose (man-rem)	
		Fish	Deer
Strontium-90	Bone	0.3	0.5
Cesium-134	Whole body	.09	1.0
Cesium-137	Whole body	.2	3.5
Cobalt-60	G I tract	NA	.1
Tritium	Whole body	.004	NA

NA, not applicable.

Tritium ingestion population dose

The population dose from the ingestion of tritiated water was estimated for the populations served by municipal water intakes along the path of the effluents from NFS. Cattaraugus Creek flows into Lake Erie at Irving, N.Y. below Buffalo; the route to the sea is north and east through the Niagara River, Lake Ontario, and the St. Lawrence Seaway. Considered in the calculation was the population served by municipal water inlets between Irving, N.Y., U.S.A. and Cornwall, Ontario, Canada.

As noted earlier, no potable water is taken from Cattaraugus Creek. However, many municipalities derive some or all of their drinking water from large intake ports in the Great Lakes and St. Lawrence River. The mouths of these intake ports are intentionally located far from shore to avoid the sewage near the coastline. The stream flow-lines are complicated, making an exact calculation of dilution factors impossible in a practical sense.

Table 12 contains the significant data used in these calculations. Dilution factors for various locations along the water pathway were obtained by simply taking the ratio of volume flow rates of the appropriate streams. These dilution factors were applied to the yearly average tritium concentration (less back-

Table 12. Drinking water—ingestion pathway—population doses due to NFS tritium releases

Location	Population served (people)	Dilution means	Flow rate (feet ^{3}/s)	Dilution factor	Average dose rate [b] (mrem/year)	Population dose (man-rem/year)
Confluence of Buttermilk and Cattaraugus Creeks [a]	—	Cattaraugus Creek	358	1.0	—	—
Lake Erie	1.35×10^6	Niagara River	195,000	1.9×10^{-3}	4.5×10^{-3}	5
Lake Ontario	2.9×10^6	St. Lawrence River	240,000	1.5×10^{-3}	3.6×10^{-3}	10
International portion of St. Lawrence River	0.2×10^6	St. Lawrence River	240,000	1.5×10^{-3}	3.6×10^{-3}	0.7
Total	4.5×10^6					16

[a] No potable water taken from Cattaraugus Creek. Yearly average (1971) tritium concentration in Cattaraugus Creek at confluence with Buttermilk Creek $= 2.8 \times 10^{-5}$ μCi/ml.

[b] Average dose rate $= 2.8 \times 10^{-5}$ μCi/ml $\times$ dilution factor $\times \frac{500 \text{ mrem/year}}{6 \times 10^{-3} \text{ μCi/ml}}$

References: (1). NFS Environmental Report No. 11.
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ground) observed in 1971 in the Cattaraugus Creek at the NFS site boundary. Doses were calculated using an ICRP whole body dose conversion factor assuming 1.1 liter per day average consumption of water from these sources; the equation is given in table 12. Except for Lake Erie, the tabled populations are those served by the municipal intake ports (*31*). For Lake Erie, the population is that of Erie and Niagara counties—although many communities undoubtedly obtain their drinking water from inland water supplies.

To place this data in its proper context, the tritium induced 16 man-rem may be compared to the ca. 540,000 man-rem accumulated from natural background radiation by the combined population.

Thyroid population dose from milk ingestion

The thyroid population dose due to the consumption of milk and milk products containing iodine-129 released from the NFS plant was estimated using certain credible assumptions. The basic assumption is that all of the milk and milk products are consumed by humans at some time. Because of the dilution of the local iodine-129 contaminated milk by uncontaminated milk in large milk pools, the average dose and the population are uncertain. However, the man-rem product is insensitive to such lack of information.

For the calculation, the average concentration of iodine-129 in the undiluted milk pool must be estimated. For this estimate, the data of Magno, et al. (*11*), obtained to corroborate the initial N.Y. State measurements (*12*), were used. The data are shown in figure 6. An easily integrable, good fit to the data is given by the expression:

$$c(r) = 2.7 \exp(-r/2) = 2.7 \exp -\lambda r.$$

The average concentration, $\bar{c}$, in the milk pool out to a radius R_o from the NFS stack is:

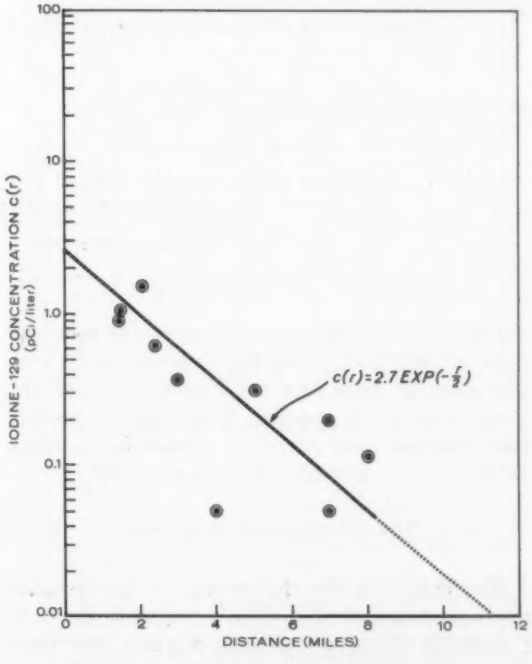

Figure 6. Iodine-129 concentration in milk, NFS environs, fall-winter 1971

$$\bar{c} = \frac{\int_0^{2\pi}\int_0^{R_0} c(r,\theta)\ \sigma\ (r,\theta)\ r\ dr\ d\theta}{\int_0^{2\pi}\int_0^{R_0} \sigma\ (r,\theta)\ r\ dr\ d\theta} \quad \ldots (6)$$

where $\sigma\ (r,\theta)$ is the volume of milk produced per unit area at distance r and angle θ about the NFS plant. According to NFS (*7*), the milk pool within 25 miles of the NFS plant is about 500,000 liters/day and this milk-producing area is heavily and rather uniformly populated by cows. For calculational purposes, it is assumed that $c(r,\theta) = c(r)$ and $\sigma\ (r,\theta) =$ constant. Under these assumptions:

$$\bar{c} \approx \frac{2\pi\int_0^{R_0} c(r)\ r\ dr}{\int_0^{R_0} 2\pi\ r\ dr} \approx \frac{5.4}{R_0^2\lambda^2} \approx 0.035\ \text{pCi/liter} \quad \ldots (7)$$

where terms of the order exp (−12.5) have been ignored and $R_0 = 25$ miles.

Having $\bar{c}$, the population dose for a population like the ICRP standard man is:
$D_p =$ (curies intake) (rem/curie) (population)

$$\approx \left[\bar{c}\,(\text{pCi/liter})\ \frac{1}{f}\,\bar{v}\ (\text{liter/d})\ \frac{365\text{d}}{2}\right] \left[\frac{30\ \text{rem/year}}{\text{MPC}_w\,(\text{pCi/liter})\ 2.2\,(\text{liter/d})\ 365\,(\text{d})}\right] \left[\frac{(f)500{,}000\ (\text{liter/d})}{\bar{v}\,(\text{liter/d-person})}\right] \quad \ldots (8)$$

where f is the dilution factor provided by other milk in the pool, $\bar{v}$ is the average daily consumption of milk and milk products, and the time involved is one-half year, approximately the time the cows were on stored feed. Using $\text{MPC}_w = 4 \times 10^{-6}\ \mu\text{Ci/ml} = 4$ nCi/liter:

$$D_p \approx 30\ \text{man-rem (thyroid)}$$

Neglected in the foregoing is the smaller average mass of the child's thyroid. Zero to 1-year-old children compose slightly less than 3 percent of the total population (*27*) and their thyroid masses average about one-tenth that of the standard man (*16*). Partially offsetting the higher potential dose due to the smaller thyroid is a smaller uptake fraction in the child's body. Overall for a given intake, the child's iodine-129 thyroid dose would be about a factor of 2 greater than that of a standard man (*32,33*). The inclusion of these factors would increase D_p as calculated above by a factor of about 1.06. Since the uncertainty of this factor is less than other uncertainties in this calculation, this correction was not made.

Conclusion and recommendations

The public documentation regarding the NFS facility operations and effluents is extensive, providing a ready, if bulky, record whereby source terms, vectors, and pathways to the exposed population can be determined. Meteorological and demographic data required for a full assessment of population dose are not as readily available. Site specific definitions of the habits of suitable sample(s) of the population, e.g., occupancy factors and consumption intakes along pathways, are virtually nonexistent, leaving much to the discretion of the individual investigator. For the NFS facility, doses to the average individual in the maximally exposed population groups were calculated using reasonable estimates of demographic factors, partially based upon EPA and New York State data.

Although many pathways to man have been considered in the foregoing, many have not. The obvious ones and some obscure ones have been considered. All of the major effluents reported by the NFS facility have been considered. Although there may be unknown pathways along which very high reconcentration factors are operable, all known ones have been analyzed herein. In the light of the intensive surveillance of the facility by many agencies, public and private, it is likely that all major pathways have been considered. Specifically not considered, however, were the very long range effects due to recycling of long-lived radionuclides, such as iodine-129 and tritium, in the troposhere.

All of the effluents and individual exposures resulting from the operation of NFS have been within the existing governmental regulations

for effluents and exposures. Continuous indepth surveillance by all involved parties has provided warnings leading to corrective actions in advance of any effluent by any pathway becoming a problem to the local population.

Based upon the analyses performed in this study, certain recommendations can be made. These are listed below without regard to cost-effectiveness or preferential order, and ignoring the already low impact of the NFS facility upon the local population.

1. The NFS plant should run its full iodine treatment system routinely, regardless of the decay of iodine-131. Iodine-129 appears in significant quantities in indicator pathways (i.e., animal thyroids) and in measurable quantities in milk; such buildup should be curtailed now.

2. Iodine-129 surveillance should be intensified. Measurement of the decontamination factor of the new NFS iodine treatment system should be given highest priority in the environmental surveillance program when the NFS plant begins new operations.

3. Surveillance of the Cattaraugus Creek system by New York State should be continued to determine whether the NFS liquid waste treatment plant is making progress in reducing radionuclide effluents.

4. Krypton-85 concentration data for the hills to the west of the NFS facility should be obtained. Although meteorological models predict little dose, the models are uncertain enough to require verification.

5. Site specific descriptions of suitable samples of the population (e.g., occupancy factors and ingestion data) should be promulgated for all nuclear facilities. These descriptions should be amenable to orderly change.

Acknowledgment

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Assessment of Doses in the Western United States from the People's Republic of China Nuclear Test of January 7, 1972

R. B. Evans, R. N. Snelling, and F. N. Buck[1]

Measurable increases in airborne radioactivity were detected in the western United States by the Air Surveillance Network (operated by the National Environmental Research Center-Las Vegas, EPA) following a nuclear detonation by the People's Republic of China on January 7, 1972. The progress and intensity of the radioactive cloud across the United States is presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 1.2 mrem at Pueblo, Colorado.

The U.S. Atomic Energy Commission has announced that the People's Republic of China detonated a nuclear device with a yield of less than 20 kilotons at its Lop Nor testing ground at approximately 2:00 a.m. e.s.t. on January 7, 1972 (*1*). Measurable increases in airborne radioactivity were subsequently detected in the western United States by the Air Surveillance Network (ASN) beginning January 10, 1972. The network, operated by the Environmental Protection Agency, National Environmental Research Center-Las Vegas, presently includes air sampling stations in 21 western States.[2] During January 1972, 103 routine stations of the ASN were operated continuously. In addition, 10 standby stations were operating (in a routine test) during most of the period, January 10 to 25, 1972.

A gross beta concentration of 2 pCi/m^3 above background first was observed in a sample collected January 10 at Bryce Canyon, Utah. The highest concentrations ultimately were found in samples from Wyoming, Colorado, Idaho, and Utah (*2*).

The highest hypothetical infant thyroid dose equivalent resulting from inhalation of iodine-131 and tellurium-132 was about 1.2 mrem at Pueblo, Colo. (*3*). The highest hypothetical infant thyroid ingestion dose equivalent estimated from concentrations of iodine-131 in milk was about 10 mrem at Laramie, Wyo. The Federal Radiation Council has recommended that the average radiation dose to the thyroids of a suitable sample of the general population be kept below 500 mrem per year. The inhalation dose equivalent of 1.2 mrem calculated for Pueblo, Colo., is about two-tenths of 1 percent of this guide. The hypothetical ingestion dose calculated for Laramie, Wyo. is about 2 percent of this guide (*4*).

Gross beta concentrations

Ten sampling stations were selected at random for a determination of background gross

[1] National Environmental Research Center-Las Vegas, U.S. Environmental Protection Agency, Las Vegas, Nev. 89114. At the time this work was performed, the Center was named the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding, No. AT(26-1)-539 with the Nevada Operations Office, U.S. Atomic Energy Commission. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

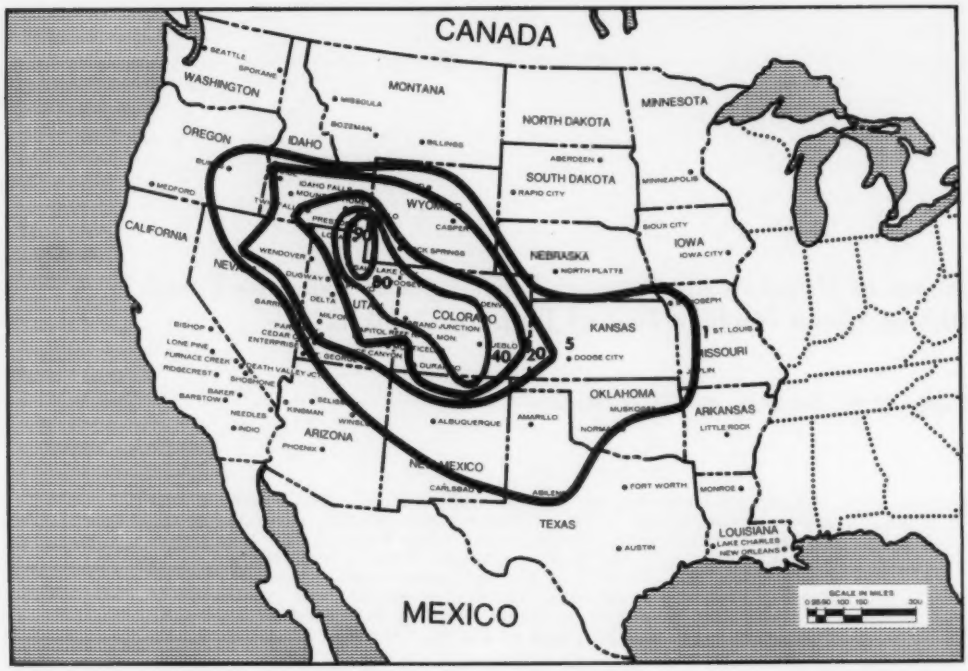

Figure 1. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 13, 1972

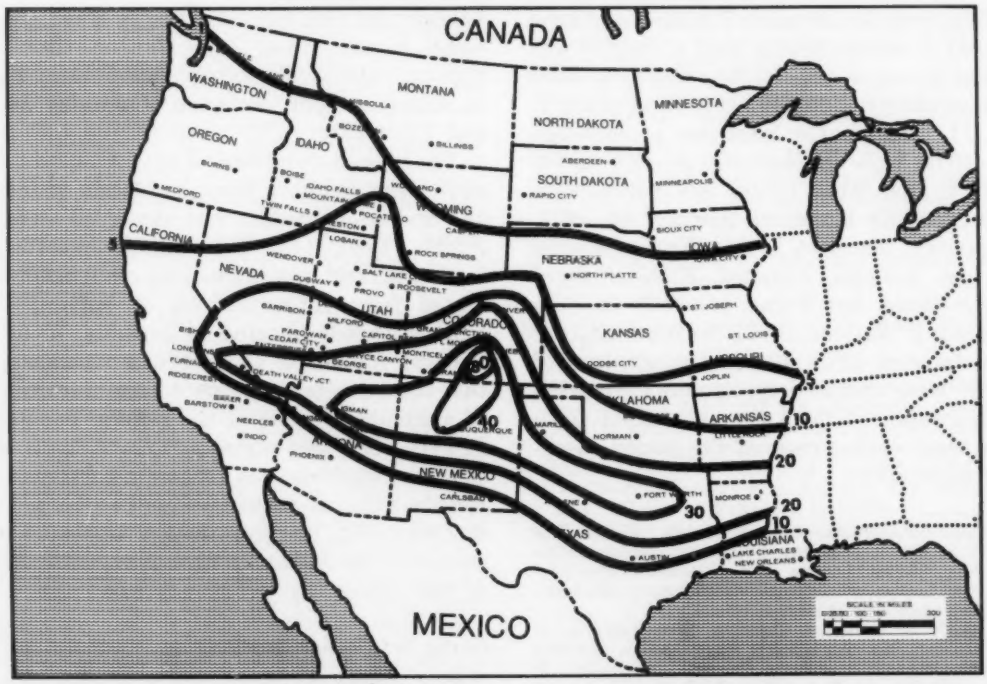

Figure 2. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 14, 1972

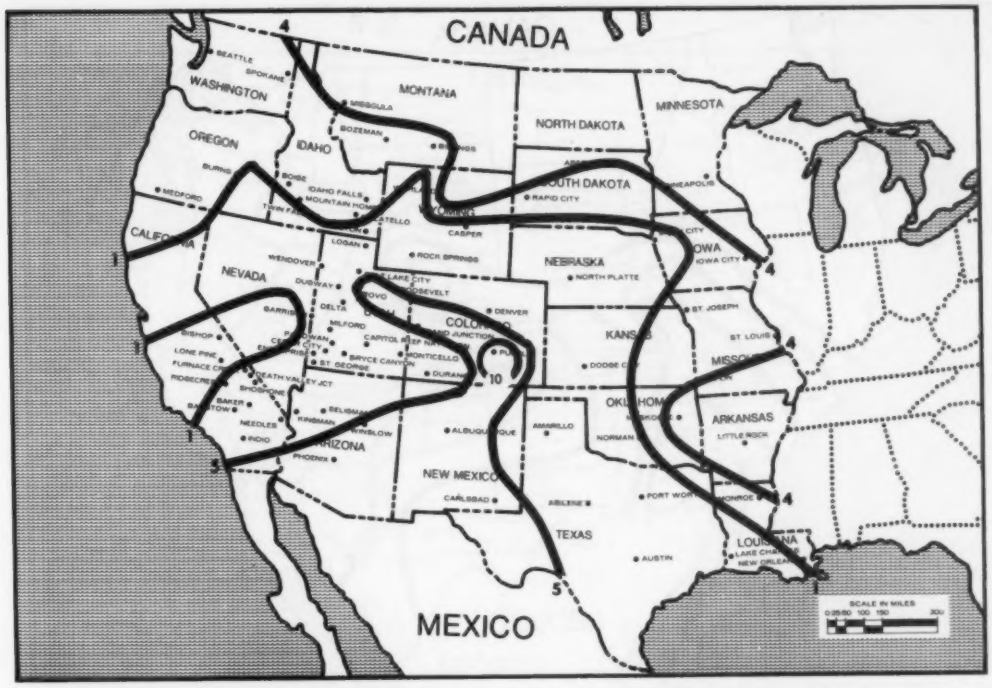

Figure 3. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 16, 1972

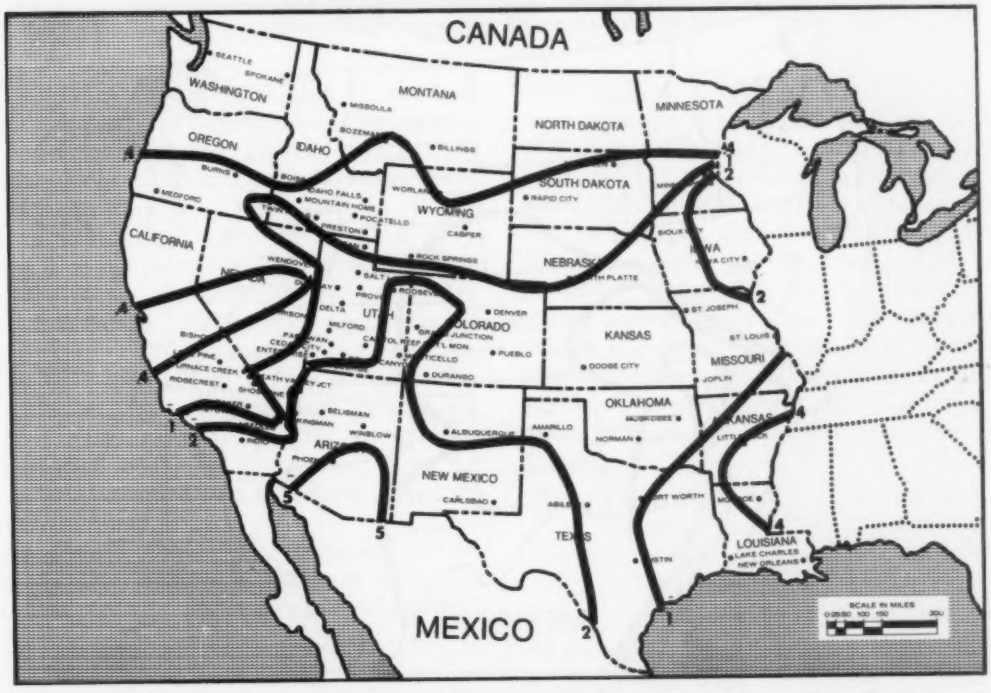

Figure 4. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 18, 1972

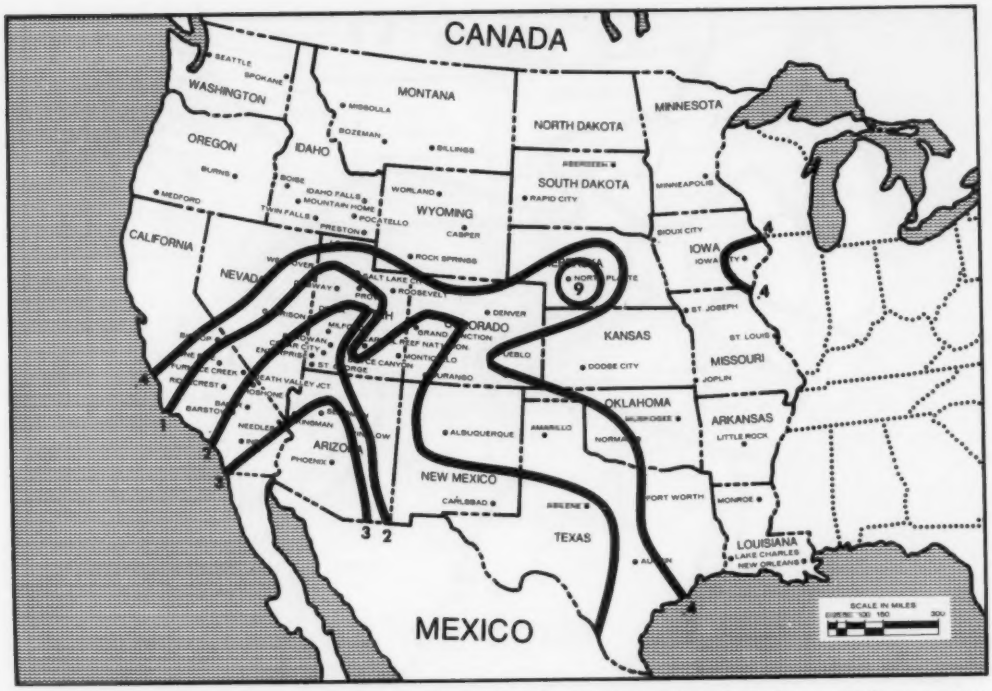

Figure 5. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 20, 1972

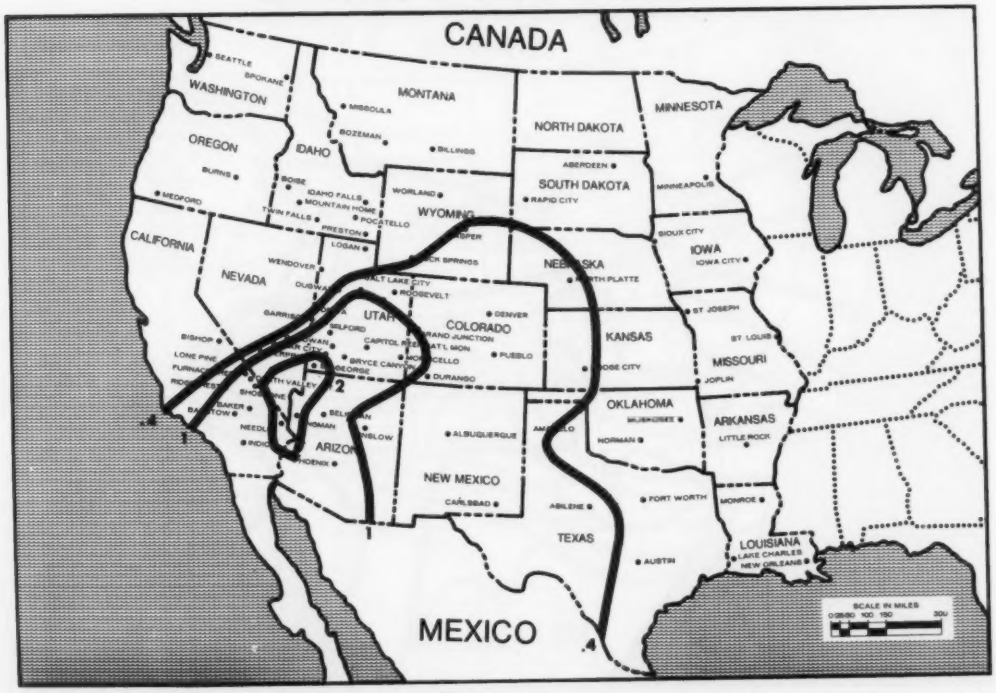

Figure 6. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 22, 1972

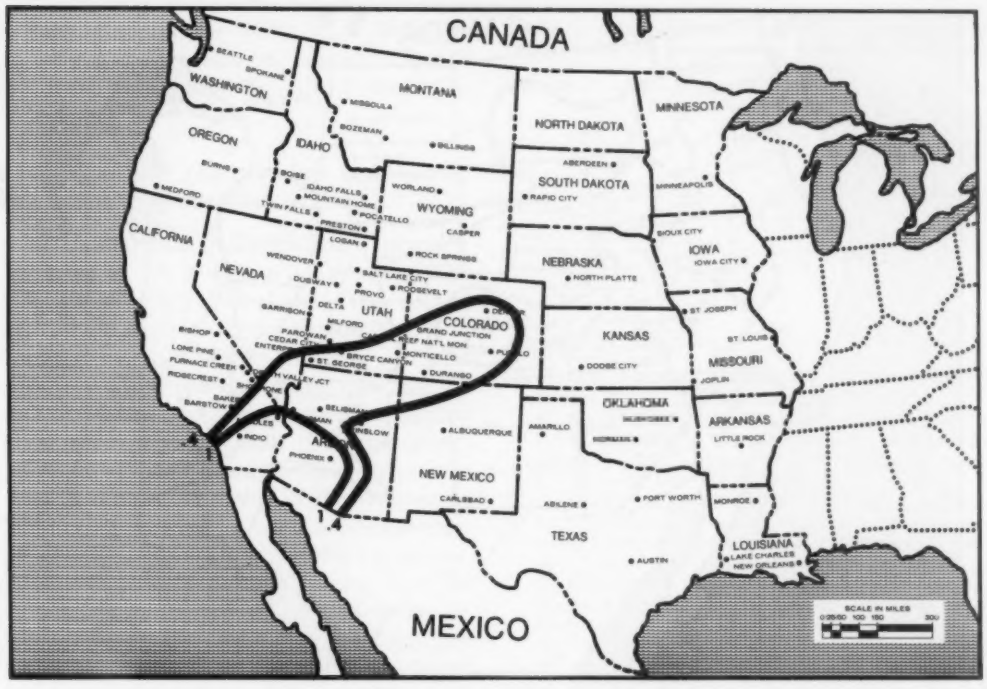

Figure 7. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 24, 1972

beta concentrations for the first 12 days of January. Values less than the minimum detectable concentration were ignored, thus raising the estimate of the average. The average gross beta concentration was found to be 0.14 pCi/m³ with an average standard deviation of 0.06 pCi/m³. For the purpose of detecting the presence of airborne radioactivity, values greater than 3-standard deviations above background (i.e., total gross beta concentration greater than 0.32 pCi/m³) were considered to be significant. Because gross beta results are reported to the nearest 0.1 pCi/m³, a gross beta concentration equal to or greater than 0.4 pCi/m³ was assumed to represent a departure from background.

Gross beta air sampling results are plotted in figures 1 through 7. By January 25th, airborne radioactivity was no longer detectable.

Composition of airborne radioactivity

Gross beta concentrations above background were measurable at 102 routine and 10 standby ASN stations. A total of 108 stations showed concentrations high enough to allow quantitation of specific isotopes by gamma spectroscopy. Radioisotopes quantitated included zirconium-95, ruthenium-103, iodine-131, tellurium-132, and barium-140. Other isotopes identified as traces too small to quantitate were molybdenum-99, cerium-141, and neodymium-147.

The highest single gross beta concentration was 91 pCi/m³ observed on a prefilter collected at Rock Springs, Wyo., between January 11 and 12. Analysis of this sample by gamma spectroscopy showed radionuclide concentrations as follows:

Zirconium-95 =	1.0 pCi/m³
Ruthenium-103 =	.7 pCi/m³
Iodine-131 =	3.0 pCi/m³
Tellurium-132 =	11.0 pCi/m³
Barium-140 =	4.5 pCi/m³

Of the above radionuclides, only iodine-131 and tellurium-132 were considered to contribute to the hypothetical infant thyroid dose equivalents represented in figure 8. Hypothetical doses

Figure 8. Hypothetical infant thyroid inhalation dose equivalent (mrem) in the western United States from the Chinese nuclear test of January 1972

from other radionuclides were much smaller than the thyroid dose and were neglected.

In contrast to the previous People's Republic of China test (November 1971), air samples from this test contained no detectable uranium-237.

Hypothetical thyroid inhalation dose equivalents

Hypothetical thyroid dose equivalents corresponding to inhalation of airborne radioactivity were computed using measured time-integrated concentrations of iodine-131 and tellurium-132, and the following dose conversion factors:

Radionuclide	*Dose conversion factor* $\left(\frac{\text{mrem-m}^3}{\mu\text{Ci-s}}\right)$
Iodine-131	0.59
Tellurium-132	.12

These dose conversion factors were derived using the models and standard man assumptions of ICRP Reports 2 and 10 (*5,6*), an assumed thyroid weight for a 1-year-old infant of 2 grams (*7*), and an assumed infant breathing rate of 4.7 m^3/day (*8*). The dose from tellurium-132 was considered to result from uptake of the daughter iodine-132 into the blood stream and subsequently into the thyroid as in ICRP 10. The computations are hypothetical in the sense that the critical receptor (a 1-year-old infant) was assumed to be present and continuously exposed to the airborne radioactivity at each location, whether or not this was actually the case.

Figure 8 shows ASN sampling stations and the isodose pattern for hypothetical infant thyroid dose equivalents in the western United States. All locations identified by name in this figure have ASN stations. The highest calculated infant dose equivalent, approximately 1.2 mrem, occurred at Pueblo, Colo. The hypothetical adult dose equivalent at that location was approximately 0.6 mrem. Adult dose equiv-

alents, calculated on the basis of a 20-gram thyroid weight and a breathing rate of 22.8 m^3/day (*8*), were approximately half of the levels shown in figure 8.

Hypothetical infant thyroid dose equivalents from ingestion of radioiodine in milk

Special Pasteurized Milk Network samples were collected at five locations in January 1972. These locations were Salt Lake City, Utah; Denver, Colo; Laramie, Wyo; Austin, Tex, and Las Vegas, Nev. Samples from three of these locations contained measurable amounts of radioiodine. These locations, peak observed iodine-131 concentrations, and the corresponding hypothetical infant thyroid dose equivalents are given in table 1. The dose equivalents were calculated on the basis of a hypothetical 1-year-old infant with a 2-gram thyroid (*7*), an assumed consumption rate of 1 liter/day (*8*) throughout the duration of radioactivity in milk, a dose conversion parameter (14.5 rem per μCi of iodine-131 ingested) derived from ICRP Reports 2 and 10, and the 5-day half-life for iodine-131 in milk recommended by FRC Report 5 (*10*).

The dose equivalents listed in table 1, also assume that the actual peak concentration in milk was that observed at each location. Because only one or two samples were collected at each location, this may not have been the case. FRC Report 5 indicates a time-to-peak for iodine-131 in milk of 2 to 4 days, depending on feeding practices. Assuming deposition occurred on January 12 and 13 when gross beta air concentrations above background were first observed in the region of the above locations, the actual peak concentrations may have been up to twice the values listed. The corresponding dose equivalents would then have been proportionally greater.

Table 1. Peak observed iodine-131 concentrations in milk samples and the corresponding hypothetical infant thyroid dose equivalents

Location	Collection date of sample (1972)	Highest observed iodine-131 concentration (pCi/liter) (*9*)	Hypothetical infant thyroid dose equivalent (mrem) (to 1 significant figure)
Denver, Colo	Jan 17	70	10
Salt Lake City, Utah	Jan 18	40	5
Laramie, Wyo	Jan 19	80	10

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SECTION I. MILK AND FOOD

Milk Surveillance, October 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 $\pm$ 0.08 g/liter for calcium and 1.51 $\pm$ 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 4 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≧ 50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≧ 20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≧ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council (FRC) for specific environmental conditions is presented below. The function of the Council was to provide guidance for the use of Federal agencies in the formulation of radiation standards. The functions of the FRC were transferred to the Environmental Protection Agency in 1970.

Radiation Protection Guides (7,8)

The Radiation Protection Guide (RPG) has been defined by the FRC as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation pro-

tection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risks to the general public that might result from exposures from routine uses of ionizing radiation and the benefits obtained from the activities causing the exposure.

FRC Reports 1 and 2 (*7,8*) set forth RPG's for specific critical organs (thyroid, bone, bone marrow, and whole body) and intake guidance for strontium-89, strontium-90, and iodine-131. At the same time, the FRC recommended that for radionuclides not specifically considered in the report, Federal agencies should use concentration values which are consistent with recommended RPG's and the general guidance on intake. Therefore, using appropriate FRC recommendations, intake guidance for cesium-137 was considered and is included in this summary.

The basic guide used for cesium-137 is 0.5 rad/year[1] as recommended for the individual in the population or 0.17 rad/year for a suitable sample of the exposed population group. Using the dose relationship for cesium-137 given in FRC Report 7 (*9*) and assuming an equilibrium condition for uptake and excretion of cesium-137 in the body, one obtains the equation:

$$D = (11)\frac{I}{W}1.44T_B$$

where, D = the dose in $\frac{\text{rads}}{\text{year}}$

I = the intake in $\frac{\mu\text{Ci}}{\text{day}}$ of cesium-137

W = the body weight in kilograms,

11 = dose conversion factor based on the absorption of 0.59 MeV per disintegration,

$1.44\,T_b$ = the mean biological life in days, and

T_b = the biological half-life in days.

[1] 0.5 rem/year is given in FRC Report No. 1 (*7*) for whole body dose. In the case of cesium-137, the rem and the rad can be taken as equivalent units.

Where milk is the vector of interest, the infant is the critical individual in the population. The continuous daily intake corresponding to a whole body dose of 0.17 rad/year is calculated to be 3,600 pCi/day, assuming the infant weighs 10 kg and the biological half-life of cesium-137 is 30 days (*9*).

For the purpose of evaluating population exposure, the daily intake of radionuclides by exposed population groups averaged over a year constitutes an appropriate criterion. However, in order to provide guidance to Federal agencies, the FRC described a graded approach involving three ranges of transient rates of daily intake as determined by surveillance, applicable to different degrees of action as follows:

Range I—periodic confirmatory surveillance as necessary;

Range II—quantitative surveillance and routine control;

Range III—evaluation and application of additional control measures as necessary.

Based on the above considerations, table 2 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable.

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk (*10,12*) one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (9,10)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the acci-

Table 2. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/year)	Guidance for suitable samples of exposed population group [a]				
			RPG (rad/year)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day) [b]	Range II (pCi/day) [b]	Range III (pCi/day) [b]
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0–20	20–200	200–2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137 [e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/year to the bone is estimated to result in a dose of 0.5 rad/year to the bone marrow.
[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

dental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

FRC Reports 5 and 7 (*9,10*) set forth PAG's for the thyroid, bone marrow, and whole body doses from ingestion of foods contaminated with radionuclides following an acute contaminating event. For the case of strontium-89, strontium-90, and cesium-137 contamination, the Council defined three categories of dietary pathways in which action may be required following an acute event as follows:

Category I—transmission of radionuclides to man through the pasture-cow-milk pathway;
Category II—transmission of radionuclides to man through dietary pathways other than the pasture-cow-milk pathway during the first year following an acute contaminating event;

Table 3. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category I (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first year; total dose not to exceed 15 [a,b]	3 in first year; total dose not to exceed 5 [a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

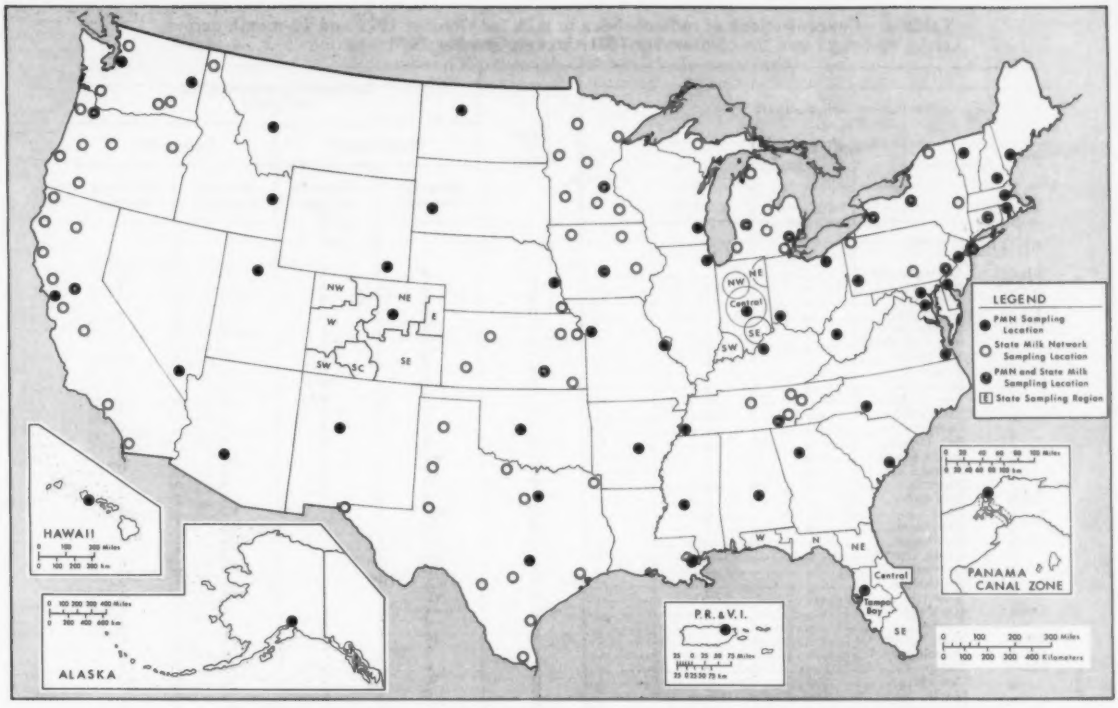

Figure 2. State and PMN milk sampling stations in the United States

Category III—long-term transmission of strontium-90 and cesium-137 through soil into plants in the years following a contaminating event.

This discussion is restricted to a consideration of Category I.

In the case of iodine-131 contamination, the maximum concentration of iodine-131 observed in milk which may occur 2 to 4 days following an acute incident, can be used to project doses for comparison to the PAG for the thyroid. For strontium-89, strontium-90, and cesium-137, the total dose to the critical organ resulting from contributions of all three of these radionuclides must be considered to determine whether the projected dose will exceed the recommended PAG for the organ of interest (bone marrow or whole body).

Based on the above conditions, table 3 represents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. Also given in table 3 are milk concentrations for each of the radionuclides considered, in the absence of the others, which if attained after an acute incident would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for an acute deposition and the pasture-cow-milk-man pathway and from an estimate of the intake prior to reaching the maximum concentration (*10*). Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples.

Data reporting format

Table 4 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 4 under each of the reported radionuclides gives the monthly average for the station and the number

Table 4. Concentrations of radionuclides in milk for October 1972 and 12-month period, November 1971 through October 1972

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	4	6	14	7
Alaska:	Palmer [c]	P	3	5	0	9
Ariz:	Phoenix [c]	P	0	0	0	0
Ark:	Little Rock [c]	P	11	11	12	6
Calif:	Sacramento [c]	P	0	1	0	0
	San Francisco [c]	P	0	1	0	0
	Del Norte	P	8	11	0	10
	Fresno	P	0	0	0	0
	Humboldt	P	2	4	0	0
	Los Angeles	P	0	5	0	0
	Mendocino	P	0	2	0	0
	Sacramento	P	0	0	0	0
	San Diego	P	0	0	0	0
	Santa Clara	P	0	0	0	0
	Shasta	P	0	2	0	0
	Sonoma	P	0	2	0	0
Colo:	Denver [c]	P	0	4	0	3
	East	R	NA		[d] 0 (2)	0
	Northeast	R	NS		NS	0
	Northwest	R	NS		NS	0
	South Central	R	NS		NS	
	Southeast	R	NS		NS	0
	Southwest	R	NA		[d] 0	0
	West	R	NS		NS	4
Conn:	Hartford [c]	P	4	5	0	7
	Central	P	6	7	0	13
Del:	Wilmington [c]	P	10	9	12	8
D.C:	Washington [c]	P	5 (2)	7	0 (2)	6
Fla:	Tampa [c]	P	5	5	40	38
	Central	R	10	5	11	40
	North	R	6	6	0	17
	Northeast	R	4	5	30	33
	Southeast	R	5	6	26	52
	Tampa Bay area	P	5	5	33	36
	West	R	10	9	15	15
Ga:	Atlanta [c]	P	NS	9	NS	11
Hawaii:	Honolulu [c]	P	0	2	0	1
Idaho:	Idaho Falls [c]	P	4	4	0	0
Ill:	Chicago [c]	P	5	5	0	9
Ind:	Indianapolis [c]	P	6	6	0	2
	Central	P	5	7	10	10
	Northeast	P	4	6	0	10
	Northwest	P	8	8	15	13
	Southeast	P	7	8	0	11
	Southwest	P	5	8	10	12
Iowa:	Des Moines [c]	P	5	4	0	1
	Des Moines	P	7	6	3 (4)	7
	Iowa City	P	9	7	0	8
	Little Cedar	P	7	7	0	11
	Spencer	P	NS	6	NS	10
Kans:	Wichita [c]	P	3	7	0	1
	Coffeyville	P	7	8	0	10
	Dodge City	P	3	5	0	8
	Falls City, Nebr	R	NS	3	NS	8
	Hays	P	5	9	0	8
	Kansas City	P	5	8	0	9
	Topeka	P	7	7	0	8
	Wichita	P	4	8	0	7
Ky:	Louisville [c]	P	6	7	0	6
La:	New Orleans [c]	P	10	13	0	5
Maine:	Portland [c]	P	7	6	29	20
Md:	Baltimore [c]	P	7	7	26	6
Mass:	Boston [c]	P	5	7	20	12
Mich:	Detroit [c]	P	6	6	0	8
	Grand Rapids [c]	P	10	8	0	7
	Bay City	P	5	5	NA	10
	Charlevoix	P	0	7	NA	11
	Detroit	P	5	4	NA	9
	Grand Rapids	P	0	5	NA	7
	Lansing	P	0	5	NA	10
	Marquette	P	4	5	NA	21
	Monroe	P	0	2	NA	4
	South Haven	P	3	5	NA	8
Minn:	Minneapolis [c]	P	6	7	0	16
	Bemidji	P	7	7	16	18
	Duluth	P	18	15	17	27
	Fergus Falls	P	7	8	11	15
	Little Falls	P	12	18	16	40
	Mankato	P	5	5	0	11
	Marshall	P	11	11	0	14

See footnotes at end of table.

Table 4. Concentrations of radionuclides in milk for October 1972 and 12-month period, November 1971 through October 1972—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—continued						
Minn:	Minneapolis	P	8	7	0	14
	Rochester	P	5	6	11	11
Miss:	Jackson [c]	P	7	9	15	7
Mo:	Kansas City [c]	P	3	5	0	3
	St. Louis [c]	P	3	6	0	3
Mont:	Helena [c]	P	3	4	0	4
Nebr:	Omaha [c]	P	4	6	0	1
Nev:	Las Vegas [c]	P	0	1	0	0
N.H:	Manchester [c]	P	7	8	11	17
N.J:	Trenton [c]	P	7	7	0	5
N. Mex:	Albuquerque [c]	P	0	1	0	0
N.Y:	Buffalo [c]	P	6	6	0	5
	New York City [c]	P	8	8	11	9
	Syracuse	P	5	6	12	7
	Albany	P	4	6	0 (5)	0
	Buffalo	P	NS		0	0
	Massena	P	NS		0	0
	New York City	P	7	7	0	0
	Syracuse	P	NS		0	0
N.C:	Charlotte [c]	P	8	9	0	8
N. Dak:	Minot [c]	P	7	9	0	9
Ohio:	Cincinnati [c]	P	5	6	0	3
	Cleveland [c]	P	8	7	0	7
Okla:	Oklahoma City [c]	P	2	5	0	5
Oreg:	Portland [c]	P	3	4	0	3
	Baker	P	5	3	[d] 0	2
	Coos Bay	P	6	4	24	5
	Eugene	P	2	1	[d] 0	1
	Medford	P	2	1	38	9
	Portland composite	P	NS	4	NS	6
	Portland local	P	NS	7	NS	7
	Redmond	P	3	2	[d] 0	2
	Tillamook	P	7	6	22	12
Pa:	Philadelphia [c]	P	6	6	0	3
	Pittsburgh [c]	P	7	9	15	6
	Dauphin	P	3	7	11	12
	Erie	P	6	7	0	12
	Philadelphia	P	3	5	11	8
	Pittsburgh	P	7	7	11	13
R.I:	Providence [c]	P	5	6	0	11
S.C:	Charleston [c]	P	8	8	15	14
S. Dak:	Rapid City [c]	P	4	7	0	3
Tenn:	Chattanooga [c]	P	7	8	11	8
	Memphis [c]	P	8	7	0	2
	Chattanooga	P	NA	10	0	12
	Clinton	R	NA	10	0	15
	Fayetteville	R	NA	10	11	7
	Kingston	R	NA	9	0	7
	Knoxville	P	NA	8	0	8
	Lawrenceburg	R	NA	8	0	9
	Nashville	P	NA	8	0	6
	Pulaski	R	NA	7	0	6
	Sequoyah	R	2	7	6	20
Tex:	Austin [c]	P	0	2	0	0
	Dallas [c]	P	5	6	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City [c]	P	3	3	0	3
Vt:	Burlington [c]	P	6	6	13	9
Va:	Norfolk [c]	P	5	6	11	7
Wash:	Seattle [c]	P	0	3	0	3
	Spokane [c]	P	3	4	0	7
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	0
	Longview	R	3	3	0	0
	Sandpoint, Idaho	R	4	9	11	14
	Skagit County	R	4	7	0	5
W. Va:	Charleston [c]	P	4	8	0	5
Wisc:	Milwaukee [c]	P	5	5	0	6
Wyo:	Laramie [c]	P	0	3	0	2

See footnotes at end of table.

Table 4. Concentrations of radionuclides in milk for October 1972 and 12-month period, November 1971 through October 1972—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		0	18
Edmonton	P	NA		15	24
British Columbia: Vancouver	P	NA		13	21
Manitoba: Winnipeg	P	NA		11	19
New Brunswick: Fredericton	P	NA		NA	NA
Newfoundland: St. John's	P	NA		19	25
Nova Scotia: Halifax	P	NA		13	18
Ontario: Ottawa	P	NA		0	10
Sault Ste. Marie	P	NA		15	25
Thunder Bay	P	NA		12	20
Toronto	P	NA		0	9
Windsor	P	NA		0	8
Quebec: Montreal	P	NA		0	13
Quebec	P	NA		10	23
Saskatchewan: Regina	P	NA		0	15
Saskatoon	P	NA		0	14
CENTRAL AND SOUTH AMERICA:					
Canal Zone: Cristobal [c]	P	0	1	0	10
Chile: Santiago	P	3	1	0	0
Colombia: Bogota	P	0	1	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Mandeville	P	5	3	32	50
Puerto Rico: San Juan [c]	P	0	1	0	4
Venezuela: Caracas	P	0	0	0	0
PMN network average [c]		5	6	4	6

[a] P, pasteurized milk.
R, raw milk
[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.
[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter
Oregon—15 pCi/liter
[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 4, surveillance results are given for strontium-90 and cesium-137 for October 1972 and the 12-month period, November 1971 to October 1972. Except where noted, the monthly average represents a single sample for

the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 4 since levels at the great majority of the stations for October 1972 were below the respective practical reporting levels. Table 5 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for October 1972, and the highest 12-month average was 18 pCi/liter (Little Falls, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 40 pCi/liter in the United States for October 1972, and the highest 12-month average was 52 pCi/liter (Southeast Florida) representing 1.4 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*11*) and Jamaica.

Table 5. Strontium-89, iodine-131, and barium-140 in milk, October 1972

Sampling location	Concentration (pCi/liter)		
	Strontium-89	Barium-140	Iodine-131
Colo: East (State)	7	36	
N.Y: New York City (State)			
Oreg: Medford (State)		13	23

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Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Milk Surveillance Programs, April-June 1972

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Milk Surveillance Network, operated by the National Environmental Research Center—Las Vegas (NERC-LV)[1] consists of about 30 sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

In the event of a release of radioactivity from the NTS, special sampling within the affected

[1] This network is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

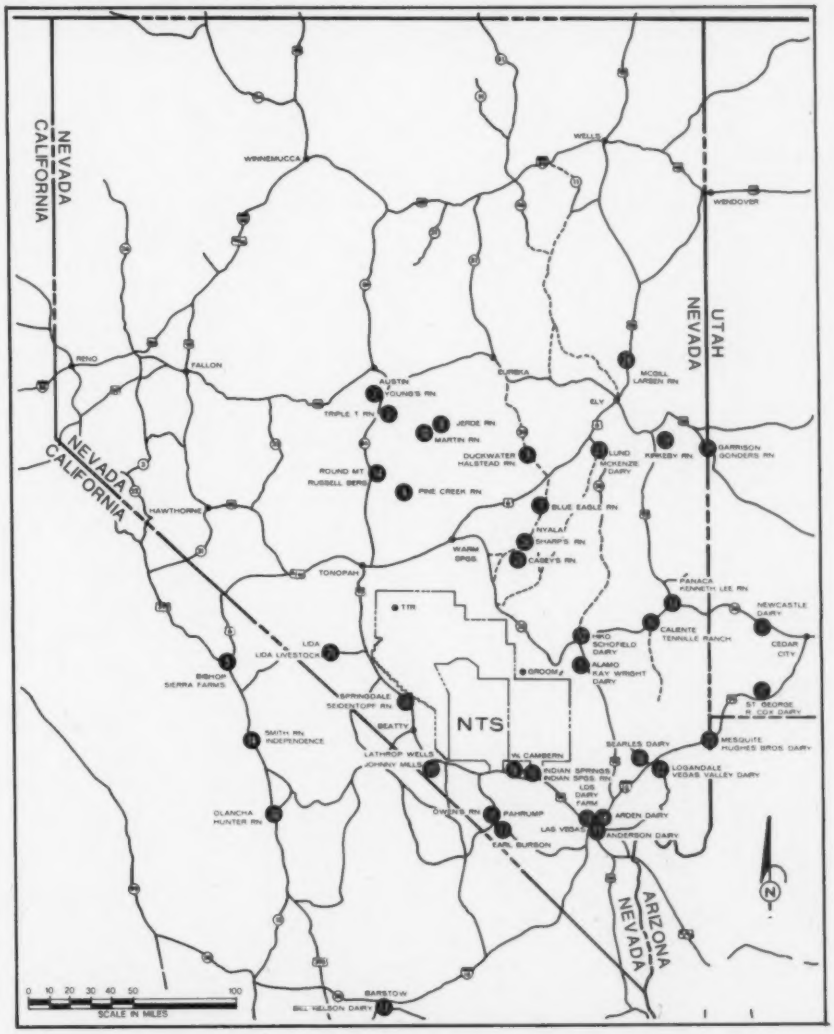

Figure 1. NERC-LV milk surveillance network

Table 1. Milk surveillance results, April-June 1972

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:							
Bishop:							
Sierra Farms	5	4/5	11	<10	<2	3 ±2	NA
		5/9	11	<10	<2	3 ±2	NA
		6/2	11	<10	2 ±2	2 ±2	NA
Hinkley:							
Bill Nelson Dairy	13	4/3	12	<10	<1	<1	NA
		5/8	12	<10	<2	<1	NA
		6/1	12	<10	2 ±2	<1	NA
Independence:							
Smith Ranch	14	4/5	13	<10	<2	2 ±1	NA
		5/9	13	<10	<2	3 ±2	NA
		6/2	13	[c] <100	2 ±2	<1	NA
Olancha:							
Hunter Ranch	30	4/5	13	<10	<3	3 ±2	NA
		5/8	13	<10	<2	<1	NA
		6/1	13	<10	<2	3 ±2	NA
Nevada:							
Alamo:							
Williams Dairy	1	4/4	12	<10	<2	2 ±1	NA
		5/5	12	<10	<2	2 ±1	NA
		6/2	12	<10	<2	<1	NA
Austin:							
Triple T Ranch	2	4/4	13	<10	<2	<1	850 ±220
		5/3	13	<10	<2	<1	500 ±220
Caliente:							
Tennille Ranch	6	5/4	13	<10	<2	3 ±1	NA
		6/1	13	<10	4 ±2	<2	NA
Currant:							
Blue Eagle Ranch	7	4/7	13	50	<2	3 ±2	NA
		5/5	13	50	<3	6 ±2	NA
		6/2	13	100	<3	6 ±2	NA
Duckwater:							
Halstead Ranch	8	4/6	13	10	<2	7 ±2	NA
		5/5	13	<10	2 ±2	2 ±2	NA
		6/1	13	<10	<2	4 ±2	NA
Eureka:							
Martin Ranch	10	4/9	13	30	4 ±3	9 ±2	NA
		5/2	13	10	5 ±4	11 ±3	NA
		6/14	13	<10	7 ±5	9 ±3	NA
Hiko:							
Schofield Dairy	12	4/4	12	<10	<2	5 ±2	230 ±190
		5/2	12	<10	<2	2 ±1	<220
		6/2	12	<10	<2	<1	380 ±210
Indian Springs:							
Cambern Ranch (A)	16	4/12	13	<10	<1	<1	NA
Indian Springs Ranch	15	5/5	13	<10	1 ±1	<1	NA
Las Vegas:							
Anderson Dairy	17	4/11	11	<10	<2	2 ±1	NA
		5/9	11	<10	<2	2 ±1	NA
		6/1	11	<10	<2	1 ±1	NA
Arden Dairy	18	4/11	11	<10	<2	3 ±1	NA
		5/9	11	<10	<2	2 ±1	NA
		6/1	11	<10	2 ±2	<1	NA
LDS Dairy Farms	19	4/12	12	<10	<2	<1	<200
		5/9	12	<10	<2	2 ±1	<220
		6/1	12	<10	<2	<1	<210
Lathrop Wells:							
Mills Ranch	20	4/11	13	<10	<2	<1	NA
		5/4	13	[c] <100	<2	2 ±1	NA
Logandale:							
Vegas Valley Dairy	22	4/4	12	<10	<2	<1	NA
		5/4	12	<10	1 ±1	<1	NA
		6/1	12	<10	<2	<1	NA
Lund:							
McKenzie Dairy	23	4/5	12	<10	<2	4 ±1	<190
		5/4	12	<10	<2	2 ±2	210 ±210
		6/2	12	<10	<3	6 ±2	300 ±210
McGill:							
Larsen Ranch	24	4/4	13	<10	<2	2 ±1	NA
		5/3	13	<10	2 ±2	<1	NA
		6/1	13	<10	<2	2 ±1	NA
Mesquite:							
Hughes Bros Dairy	25	4/4	12	<10	<2	<1	200 ±190
		5/4	12	<10	2 ±2	<1	<220
		6/1	12	<10	1 ±1	<1	410 ±220
Moapa:							
Searles Dairy	26	4/4	12	<10	<2	2 ±1	NA
		6/20	12	<10	<2	2 ±2	NA
Nyala:							
Sharp's Ranch	28	4/5	13	<10	<2	3 ±1	<220
		5/3	13	<10	<2	2 ±1	<220
		6/1	13	<10	<2	4 ±2	<200

See footnotes at end of table.

Table 1. Milk surveillance results, April-June 1972—continued

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
Pahrump:							
Owens Ranch	31	4/11	13	<10	<1	<1	NA
		5/4	13	<10	<2	<1	NA
		6/2	13	<10	<2	<1	NA
Panaca:							
Kenneth Lee Ranch	33	4/5	13	10	<2	4 ±2	NA
		5/3	13	<10	<2	4 ±1	NA
		6/1	13	<10	<2	3 ±2	NA
Round Mt:							
Russell Berg	34	4/4	13	20	<3	7 ±2	NA
		6/1	13	10	<2	6 ±2	NA
Shoshone:							
Kirkeby Ranch	35	4/4	13	10	<2	6 ±2	NA
		5/8	13	<10	<2	4 ±2	NA
		6/1	13	<10	3 ±3	6 ±2	NA
Springdale:							
McCurdy Ranch	36	4/12	13	<10	<2	2 ±1	NA
Seidentopf Ranch	36	5/4	13	[c] <100	3 ±2	<1	NA
		6/2	13	<10	2 ±2	<1	NA
Utah:							
Garrison:							
Gonders Ranch	11	4/4	13	<10	<2	2 ±1	NA
		5/8	13	<10	<2	2 ±1	NA
		6/1	13	<10	2 ±2	2 ±1	NA
Newcastle:							
Newcastle Dairy	27	4/6	12	10	<2	3 ±1	NA
		5/3	12	<10	<2	2 ±1	NA
St. George:							
R. Cox Dairy	37	4/5	12	20	<2	3 ±1	NA
		5/4	12	<10	<2	<1	NA
		6/2	12	<10	2 ±2	<1	NA

[a] 11, pasteurized milk.
12, raw milk from Grade A producer(s).
13, raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size.
A, alternate milk sampling station.
NA, not analyzed.

area is conducted to determine radionuclide concentrations and to take protective action, if required. Other sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the December 1972 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in April, May, and June 1972 by NERC-LV surveillance programs are listed in table 1. With the exception of cesium-137 at levels near the minimum detectable activity (10 pCi/liter), no gamma-emitting fission products were detected in any of the samples by gamma spectroscopic analysis. Levels of tritium, strontium-89, and strontium-90 near the MDA's for these radionuclides (approximately 200 pCi/liter, 2 pCi/liter, and 1 pCi/liter, respectively) were also measured by radiochemistry analyses.

Copies of these results were distributed to EPA Regional Offices and appropriate State agencies prior to publication.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January-June 1971	December 1972
Carbon-14 in Total Diet and Milk	July-December 1971	May 1972
Connecticut Standard Diet	January-December 1971	December 1972
	This network has been discontinued.	
Institutional Total Diet	October-December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January-December 1971	November 1972
Strontium-90 in Tri-City Diets	January-December 1971	December 1972

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Michigan	January-June 1970	November 1971
Minnesota Municipal Water	July 1970-June 1971	November 1972
New York	July-December 1970 and January-June 1971	May 1972
North Carolina	1968-1970	September 1972
Radiostrontium in Tap Water	July-December 1971	November 1972
Tritium Surveillance System	April-June 1972	January 1973
Washington	July 1969-June 1970	March 1972
Water Surveillance Programs	January-March 1972	December 1972

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radioactivity in Kansas Surface Waters January-December 1971

Radiation Control Section
Kansas State Department of Health

Monitoring of levels of radioactivity in the surface waters of Kansas is analyzed by the Kansas State Department of Health, Radiation Control Section, in cooperation with the Kansas Water Quality Control Section and the U.S. Geological Survey. This surveillance program is important because of both the present and future potential use of Kansas surface waters for domestic, recreational, and industrial purposes.

Liter samples are collected every month at each location shown in figure 1. These samples are analyzed for gross alpha and beta radioactivity. In order to establish baseline data in anticipation of the two power reactors which will be located on the Missouri River in Nebraska, each Missouri River sample is gamma scanned for specific radionuclides. Specific radionuclide analyses are also performed on any other samples which indicate high gross alpha-beta activity. Radioactivity in these waters consists of the natural radioactivity picked up by flowing streams, radioactivity from sewage discharge into the streams, and some contribution by industrial waste. The final contributing factor to radioactivity content is fallout, particularly over large expanses of open water, such as reservoirs and lakes.

Analytical procedures

Radioactivity analyses are performed by the Kansas Radiation Laboratory. Measurements of gross alpha-plus-beta radioactivity are made with a windowless gas-flow proportional counter. Each sample is evaporated in an aluminum planchet, dried at 250°C, and then counted. Specific radionuclide analyses are determined by gamma spectroscopy or chemical separation.

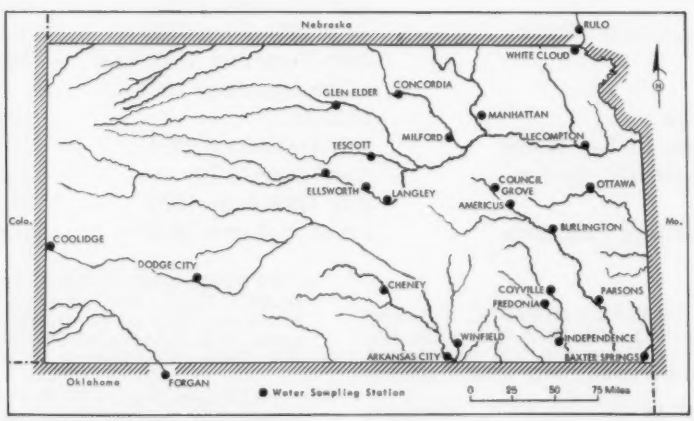

Figure 1. Kansas surface water sampling stations

Table 1. Gross radioactivity in Kansas surface waters, January-June 1971

Rivers	Sampling stations	Radioactivity concentration (pCi/liter)											
		January		February		March		April		May		June	
		Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Arkansas	Arkansas City	3	16	22	0	3	2	10	0	0	0	3	3
	Dodge City	55	0	61	32	56	0	31	0	20	9	24	[a]21
	Coolidge	55	21	41	0	49	8	16	17	66	0	39	18
Big Blue	Manhattan	3	14	NS	NS	2	11	3	10	4	30	3	11
Fall	Fredonia	0	12	1	16	3	12	2	0	0	7	4	14
Kansas	Lecompton	4	13	3	21	3	0	4	13	2	5	6	1
Marais Des Cygnes	Ottawa	NS	NS	2	8	4	0	1	18	1	7	3	6
Missouri	Rulo, Nebr.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	White Cloud	6	0	12	14	8	0	9	5	11	23	9	26
Neosho	Americus	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Burlington	6	7	NS	NS	2	11	5	4	NS	NS	4	1
	Council Grove	NS	NS	4	14	0	6	5	3	4	0	NS	NS
	Parsons	3	2	1	0	3	7	5	6	2	2	0	6
Ninnescah	Cheney Reservoir	1	4	1	7	1	9	9	6	2	0	8	3
	Peck	2	4	0	0	2	2	8	0	0	13	4	17
Republican	Concordia	NS	NS	5	11	8	3	7	25	15	9	5	17
	Milford	4	18	11	10	7	5	7	18	4	31	6	24
Saline	Tescott	3	6	2	14	0	0	8	4	13	0	11	13
Smoky Hill	Ellsworth	13	23	6	0	0	0	14	60	9	20	3	19
	Langley	6	14	4	3	3	0	5	19	8	9	5	9
Solomon	Glen Elder	7	[a]40	3	[a]42	6	28	9	16	10	16	2	37
Spring	Baxter Springs	1	0	0	2	1	1	0	1	NS	NS	2	7
Verdigris	Coyville	1	8	0	7	0	4	2	8	5	2	1	8
	Independence	0	0	4	2	3	0	1	8	4	4	2	0
Walnut	Winfield	4	0	0	5	12	2	6	0	4	2	NS	NS

Table 1. Gross radioactivity in Kansas surface waters, July-December 1971—continued

Rivers	Sampling stations	Radioactivity concentration (pCi/liter)											
		July		August		September		October		November		December	
		Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Arkansas	Arkansas City	8	3	1	0	0	9	NS	NS	7	11	11	9
	Dodge City	32	7	48	12	28	13	25	16	1	34	21	42
	Coolidge	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Big Blue	Manhattan	3	11	0	20	2	0	0	18	0	6	1	1
Fall	Fredonia	4	15	0	9	2	0	2	0	0	6	1	1
Kansas	Lecompton	0	0	0	60	NS	NS	2	0	1	7	1	0
Marais Des Cygnes	Ottawa	2	7	0	18	0	0	1	22	1	0	8	16
Missouri	Rulo, Nebr.	7	0	9	7	8	13	8	0	13	13	10	16
	White Cloud	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Neosho	Americus	NS	NS	NS	NS	NS	NS					NS	NS
	Burlington	4	11	3	12	1	1	2	20	3	12	NS	NS
	Council Grove	4	1	NS	NS	NS	NS	NS	NS	NS	NS	4	22
	Parsons	1	12	0	6	3	0	1	0	4	11	NS	NS
Ninnescah	Cheney Reservoir	7	0	0	20	3	32	5	27	5	30	1	1
	Peck	4	11	1	0	0	0	1	0	2	19	7	9
Republican	Concordia	9	22	2	9	10	4	2	12	7	4	4	13
	Milford	4	8	5	14	4	6	10	0	0	2	NS	NS
Saline	Tescott	0	27	9	0	13	12	14	0	2	34	12	38
Smoky Hill	Ellsworth	3	0	4	17	0	0	10	3	8	0	10	37
	Langley	0	15	0	7	5	6	1	24	15	3	5	19
Solomon	Glenn Elder	NS	NS	NS	NS	6	24	9	24	7	23	5	5
Spring	Baxter Springs	NS	NS	1	0	1	0	1	0	3	13	4	5
Verdigris	Coyville	6	10	3	17	3	6	0	0	1	8	0	11
	Independence	1	8	2	18	0	0	0	6	1	9	0	19
Walnut	Winfield	5	15	0	0	5	5	1	0	2	0	2	31

[a] Gamma scan performed, but activity not sufficient to permit identification of specific radionuclides.
NS, no sample.

Discussion

Table 1 shows the gross alpha and gross alpha-plus-beta radioactivity in the total solids in Kansas surface waters from January through December 1971. These waters are used for domestic, industrial, and recreational purposes. The Arkansas River samples have consistently high activity which is attributed to uranium picked up from its drainage in Colorado.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1970	December 1971

Tritium Surveillance System, July-September 1972

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the Tritium in Surface Water Network. This network was established in 1964 to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for January-June 1970, have been published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the Office of Air Programs of EPA. The data from this project for July-December 1969 have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 70 drinking water samples collected quarterly at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and surface samples collected quarterly at 39 surface water

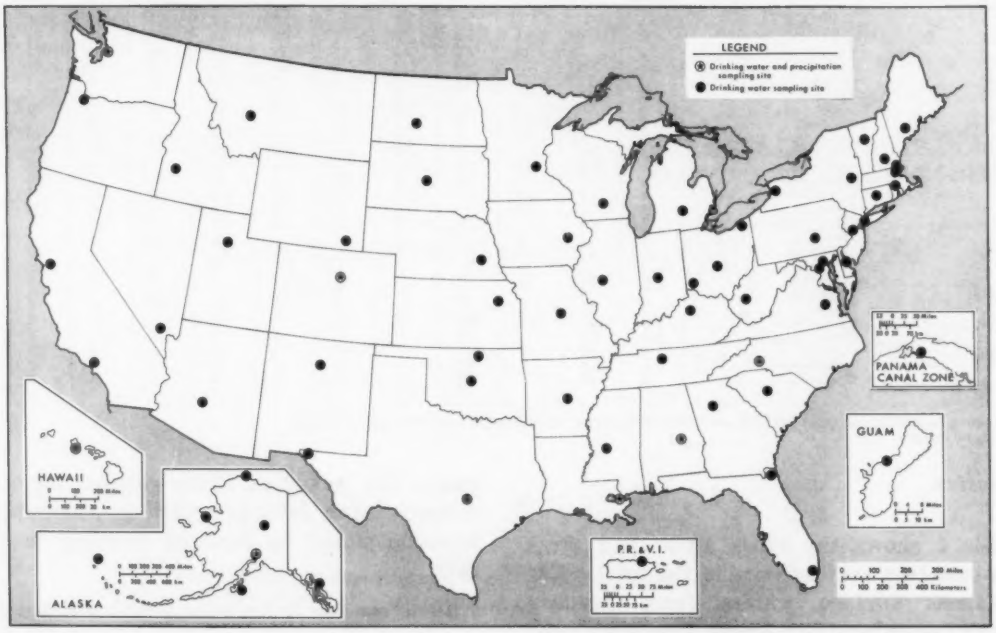

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

sampling systems stations (figure 2). The specific locations for the surface were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to either the Eastern Environmental Radiation Laboratory or the National Environmental Research Center—Las Vegas, for analysis. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for July-September 1972. The average tritium concentration was 0.3 nCi/liter.

Previous articles on the Tritium Surveillance System have reported dose equivalents from tritium in body water based on a relationship derived by Moghissi and Porter (*3*). Their relationship assumed a quality factor of 1.7 for tritium beta rays based on a 1966 ICRP recommendation (*4*). Recently the NCRP has recommended a quality factor of 1 for tritium beta rays (*5*) and this recommendation has been adopted for this and subsequent reports. Following the notation adopted by the ICRU (*6*) substitution of a quality factor of 1 in Moghissi and Porter calculations yields:

$$H \text{ (mrem/year)} = 0.1C \text{ (nCi/liter)}$$

Where H is the dose equivalent rate and C represents the tritium concentration in body water.

Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

Table 1. Tritium concentration in tap water (RAN stations, July-September 1972

Location		Date collected (1972)	Tritium concentration [a] (nCi/liter ± 2 σ)[b]
Ala:	Montgomery	7/12	0
Alaska:	Anchorage	7/5	.6
	Attu Island	NS	
	Fairbanks	NS	
	Juneau	7/11	.3
	Kodiak	7/5	0
	Nome	7/3	.6
	Point Barrow	7/5	.7
Ariz:	Phoenix	7/5	0
Ark:	Little Rock	7/3	.7
Calif:	Berkeley	7/5	.5
	Los Angeles	7/7	0
C.Z:	Ancon	7/21	0
Colo:	Denver	7/6	.9
Conn:	Hartford	7/3	0
Del:	Dover	7/5	0
D.C:	Washington	7/12	0
Fla:	Jacksonville	7/3	0
	Miami	7/5	0
Ga:	Atlanta	7/5	.2
Guam:	Agana	7/3	0
Hawaii:	Honolulu	7/3	.7
Idaho:	Boise	7/3	.3
Ill:	Springfield	7/3	.3
Ind:	Indianapolis	7/5	0
Iowa:	Iowa City	7/3	.6
Kans:	Topeka	7/6	0
Ky:	Frankfort	7/26	.3
La:	New Orleans	7/7	.4
Maine:	Augusta	7/12	.3
Md:	Baltimore	7/3	0
Mass:	Lawrence	7/5	.3
	Winchester	7/3	.4
Mich:	Lansing	7/11	0
Minn:	Minneapolis	7/6	.6
Miss:	Jackson	7/5	0
Mo:	Jefferson City	7/18	0
Mont:	Helena	7/10	.4
Nebr:	Lincoln	7/6	0
Nev:	Las Vegas	7/5	1.6
N.H:	Concord	7/5	.3
N.J:	Trenton	7/5	.2
N. Mex:	Sante Fe	7/10	.3
N.Y:	Albany	7/5	.2
	Buffalo	7/7	.4
	New York City	7/3	0
N.C:	Gastonia	7/5	.2
N. Dak:	Bismarck	7/7	.9
Ohio:	Cincinnati	7/5	.3
	Columbus	7/14	.2
	Painesville	7/5	.4
Okla:	Oklahoma City	7/3	.8
	Ponca City	7/5	.5
Oreg:	Portland	7/3	.4
Pa:	Harrisburg	7/7	.3
P.R:	San Juan	7/5	0
R.I:	Providence	7/7	.2
S.C:	Columbia	7/5	0
S. Dak:	Pierre	7/5	1.0
Tenn:	Nashville	7/3	.2
Tex:	Austin	7/3	0
	El Paso	7/5	1.0
Utah:	Salt Lake City	7/5	.9
Vt:	Barre	7/5	.2
Va:	Richmond	7/7	.3
Wash:	Seattle	7/6	.3
	Spokane	7/3	.8
W. Va:	Charleston	7/5	.2
Wisc:	Madison	7/7	0
Wyo:	Cheyenne	7/5	1.0
Average			0.3

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.
[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.
NS, no sample.

Table 2. Tritium concentration in surface water, July-September 1972

Location		Water source	Facility	Collection date (1972)	Concentration [a] (nCi/liter ± 2σ)[b]
Ala:	Decatur	Tennessee River	Browns Ferry	7/31	0.4
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	7/5	.4
Calif:	Eureka	Humboldt Bay	Humboldt Bay	8/25	0
	San Onofre	Pacific Ocean	San Onofre	7/19	.4
Colo:	Greely	South Platte River	Fort St. Vrain	7/6	1.1
Conn:	East Haddam	Connecticut River	Connecticut Yankee & Vermont Yankee	7/18	.7
	Waterford	Long Island Sound	Millstone	7/18	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	7/6	0
	Homestead	Biscayne Bay	Turkey Point	8/30	0
Idaho:	Buhl	Snake River	National Reactor Testing Station	7/3	.3
Ill:	Moline	Mississippi River	Quad-Cities	7/11	.4
	Morris	Illinois River	Dresden and Argonne	7/12	.3
La:	New Orleans	Mississippi River	(Several)	7/5	.7
Md:	Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	7/6	.4
	Lusby	Chesapeake Bay	Calvert Cliffs	7/6	.2
Mass:	Rowe	Deerfield River	Yankee	7/18	2.3
Mich:	Charlevoix	Lake Michigan	Big Rock Point	7/21	.2
	Monroe	Lake Erie	Enrico Fermi	7/20	.3
	South Haven	Lake Michigan	Palisades	7/18	1.2
Minn:	Monticello	Mississippi River	Monticello	7/6	.5
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	7/26	.7
Nev:	Boulder City	Colorado River	Background	7/10	1.0
N.J:	Bayside	Delaware River	Salem	7/5	0
N.Y:	Ossining	Hudson River	Indian Point	7/10	.3
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	7/5	.3
	Poughkeepsie	Hudson River	Background	7/12	.3
N.C:	Charlotte	Catawba River	Wm. B. McGuire	NS	
Oreg:	Westport	Columbia River	Rainier and Hanford	7/13	.5
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	6/28 [c]	2.0
	Hartsville	Lake Robinson	H. B. Robinson	7/7	2.2
Tenn:	Kingston	Clinch River	Oak Ridge	7/31	.9
Tex:	El Paso	Rio Grande	Los Alamos	7/5	.4
Vt:	Vernon	Connecticut River	Vermont Yankee	7/6	.3
Va:	Newport News	James River	Surry	7/5	0
Wash:	Northport	Columbia River	Background	7/12	.8
	Pasco	Columbia River	Hanford	7/6	.6
W. Va:	Wheeling	Ohio River	Shippingport	7/25	.3
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	7/12	.2
	Victory	Mississippi River	LaCrosse and Prairie Island	7/10	.4
	Average				0.6

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.
[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.
[c] Sample collected early.
NS, no sample.

The highest individual concentration of tritium observed in the drinking water was 1.6 nCi/liter during the third quarter. This corresponds to a dose of 0.16 mrem/a, or less than 0.09 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 2.3 nCi/liter for the third quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.23 mrem/a, or 0.14 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

Table 3. Tritium concentration in precipitation from RAN stations, July-September 1972

Location		Tritium concentration [a] (nCi/liter ± 2σ)		
		July	August	September
Ala:	Montgomery	0	0	0
Alaska:	Anchorage	0	0	0
Colo:	Denver	0.5	0.4	0.2
Hawaii:	Honolulu	0	0	0
La:	New Orleans	0	0	0
N.C:	Gastonia	.2	NS	.2
Tex:	Austin	0	0	0
Wash:	Seattle	0	0	0

[a] The minimum detection limit for these samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero. The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.
NS, no sample.

Other coverage in *Radiation Data and Reports:*

Period	Issue
July-September 1971	April 1972
October-December 1971	May 1972
January-March 1972	August 1972
April-June 1972	January 1973

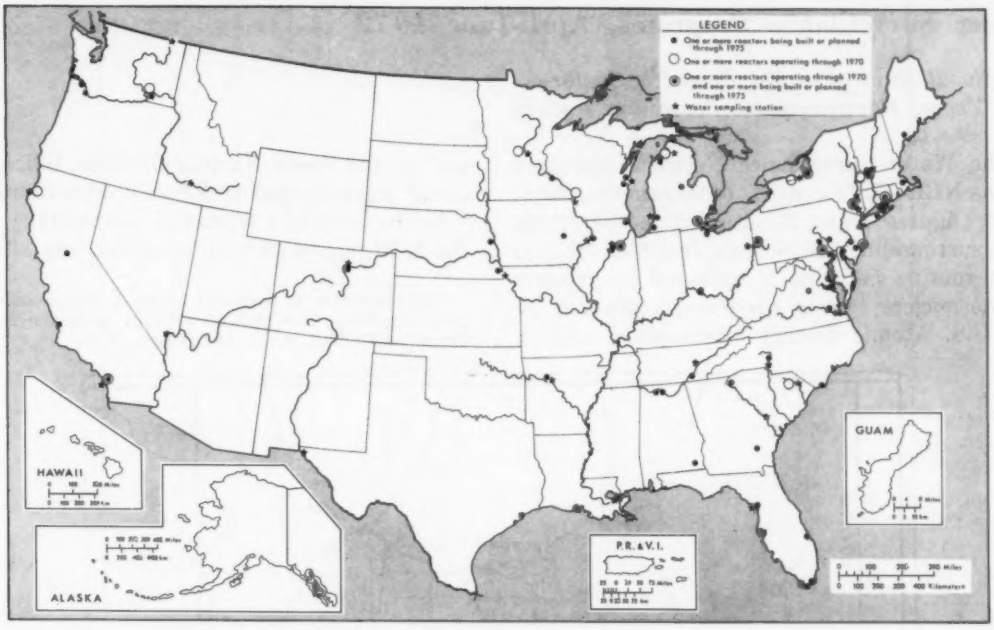

Figure 2. Surface water sampling locations for tritium surveillance system

REFERENCES

(*1*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January-June 1970. Radiol Health Data Rep 11:638–639 (November 1970).

(*2*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July-December 1969. Radiol Health Data Rep 11: 354–355 (July 1970).

(*3*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9: 337–339 (July 1968).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the International Commission on Radiological Protection (Adopted September 17, 1965), ICRP Publication 9 (1969).

(*5*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Basic Radiation Protection Criteria, NCRP Report No. 39. National Council on Radiation Protection and Measurements, Washington, D.C. 20008 (January 15, 1971).

(*6*) INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Radiation quantities and units, ICRU Report No. 19, Washington, D.C. 20014 (July 1972).

Water Surveillance Programs, April-June 1972

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Water Surveillance Network, operated by the NERC-LV,[1] consists of 90 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space administration.

In the event of a release of radioactivity from the NTS, special sampling within the affected

[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

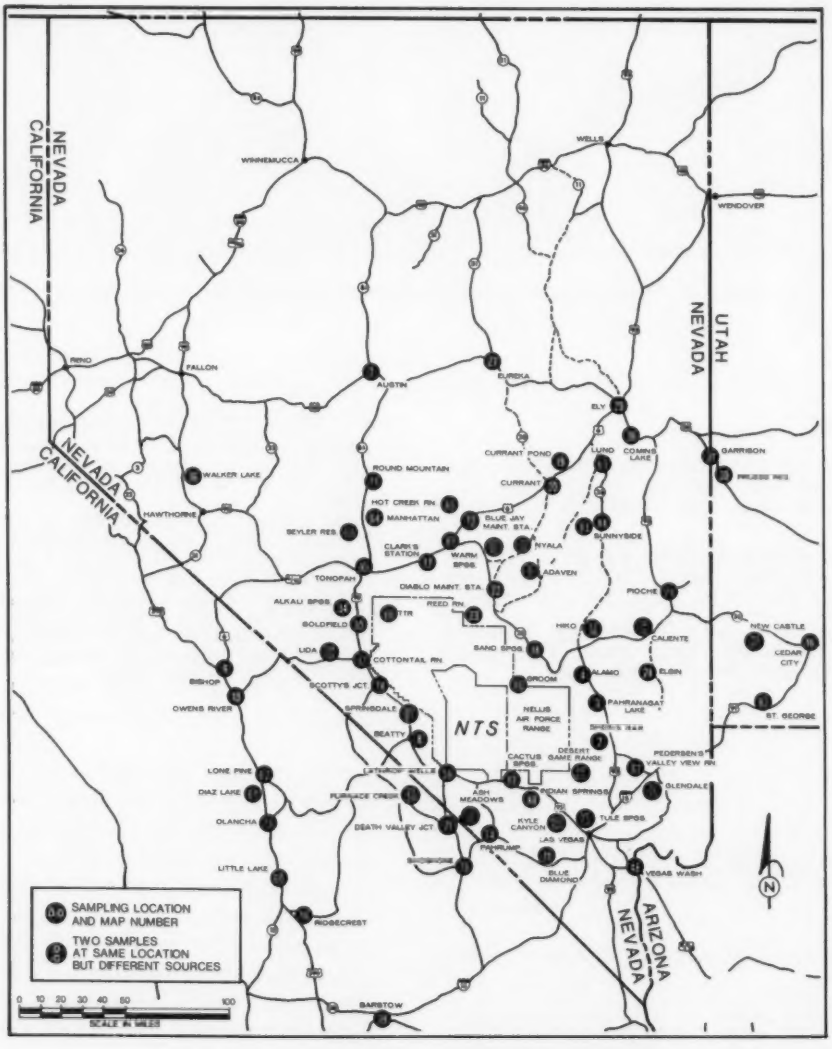

Figure 1. NERC-LV water surveillance network

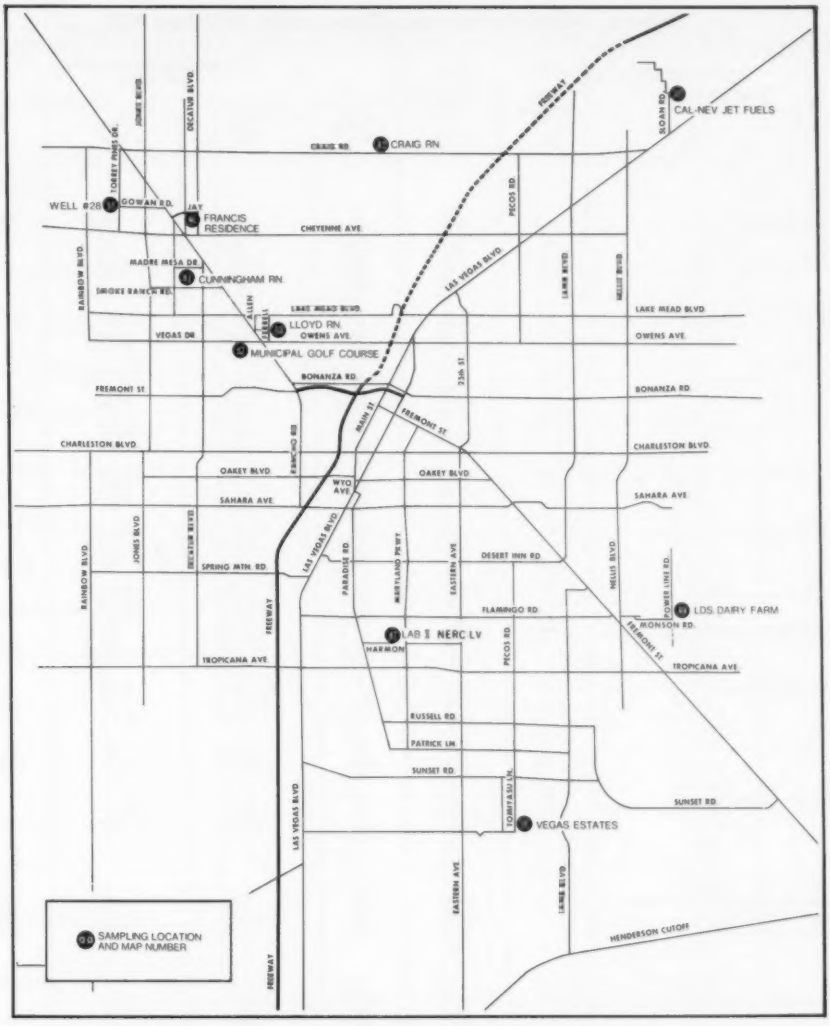

Figure 2. Water surveillance network, Las Vegas valley

area is conducted to determine radionuclide concentrations and to take protective action, if required. Other sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the water results reported in the December 1972 issue of *Radiation Data and Reports.*

Results

The analytical results of all water samples collected in April, May, and June 1972 by the NERC-LV Water Surveillance Network are listed in table 1, including three samples collected in Colorado in support of Project Rulison. No gamma-emitting fission products were detected in any of the samples by gamma spectroscopy analysis.

Table 2. NERC-LV water surveillance results, April-June 1972

Location	Map number	Date collected (1972)	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
California:						
Bishop:						
Fish & Game Office	9	4/5	23	<2.8	<3.3	NA
		5/9	23	<1.3	<3.2	NA
		6/2	23	<2.4	<3.4	NA
Owens River, 3 miles East	10	4/5	22	5±4	4±3	NA
		5/9	22	5±3	5±3	NA
		6/2	22	<4.1	<3.4	NA
Death Valley Junction:						
Lila's Cafe	21	4/6	23	<6.5	10±3.8	<220
		5/10	23	<5.3	8±4	<220
		6/2	23	<8.8	9±4	<220
Furnace Creek:						
Pond	28	4/6	21	6±5	11±3.7	NA
		5/10	21	<3.7	9±4	NA
		6/2	21	<6.8	6±4	NA
Visitors Center	29	4/6	27	<6.3	8±4	NA
		5/10	27	4±4	11±3.8	NA
		6/2	27	<6.8	7±4	NA
Hinkley:						
Bill Nelson Dairy	39	4/3	23	<4.7	10±4	NA
		5/8	23	9±5	7±4	NA
		6/1	23	<6.9	6±4	NA
Little Lake:						
Little Lake Ranch	60	4/4	21	<8.7	24±4.7	NA
		5/8	21	<5.2	25±4.5	NA
		6/1	21	<8.3	<3.6	NA
Lone Pine:						
Diaz Lake	61	4/4	21	13±6.9	19±4.2	NA
		5/8	21	14±6.9	35±4.9	NA
		6/1	21	17±8.9	24±4.7	NA
Forest Service Ranger Station	62	4/5	23	<3.2	<3.3	NA
		5/8	23	<1.5	<3.2	NA
		6/1	23	<2.0	<3.2	NA
Olancha:						
Haiwee Reservoir	73	4/4	21	29±7.5	6±3	NA
		5/8	21	6±3	5±3	NA
		6/1	21	<3.9	9±4	NA
Ridgecrest:						
City Hall	76	4/4	23	<4.0	3±3	NA
		5/8	23	<2.7	<3.3	NA
		6/1	23	<5.6	9±4	NA
Shoshone:						
Chevron Service Station	79	4/6	27	<6.3	19±4.2	NA
		5/10	27	7±5	21±4.5	NA
		6/2	27	<8.2	15±4.3	NA
Colorado:						
Grand Valley:						
Battlement Creek above Test Well [c]		4/23	22	NA	NA	550±230
Battlement Creek [c]		4/23	22	NA	NA	710±230
Claude Hayward Cabin [c]		4/23	27	NA	NA	300±220
Nevada:						
Adaven:						
Canfield Ranch	1	4/5	22	5±3	4±3	NA
		5/3	22	5±3	4±3	NA
		6/1	22	<4	<3.4	NA
Alamo:						
Sheri's Bar	2	4/4	23	<4.4	<3.4	NA
		5/5	23	4±3	<3.3	NA
		6/2	23	<4	5±3	NA
Pahranagat Lake	3	4/4	21	17±8	18±4.3	NA
		5/5	21	11±5.8	21±4.4	NA
		6/1	21	15±7.9	30±4.7	NA
Williams Dairy	4	4/4	23	<5	13±3.8	NA
		5/5	23	<3.4	11±3.8	NA
		6/2	23	<5.7	15±3.9	NA
Ash Meadows:						
Ash Meadows Lodge	5	4/10	23	NA	NA	<220
		5/3	23	9±5	18±4.2	<210
		6/1	23	10±9	17±4.4	<200
Ash Meadows Pond	6	4/10	21	<7.5	27±4.7	NA
		5/3	21	12±6	23±5	NA
		6/1	21	NA	15±4	NA
Austin:						
County Court House	7	4/5	27	25±6.3	16±4	NA
		5/4	27	23±6.5	24±4.3	NA
		6/2	27	21±7.0	15±4.1	NA
Beatty:						
Richfield Service Station	8	4/6	23	11±6.4	9±4	<220
		5/2	23	13±7.4	12±3.9	<210
		6/1	23	<8.3	9±4	<200

See footnotes at end of table.

Table 2. NERC-LV water surveillance results, April-June 1972—continued

Location	Map number	Date collected (1972)	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada (continued)						
Blue Diamond:						
Post Office	11	4/10	23	<4.2	<3.1	240 ±210
		5/5	23	6±4	3.2	<220
		6/2	23	<5.5	<3.5	<200
Blue Jay Highway Maintenance Station	12	4/5	23	5±4	8±4	NA
		5/3	23	9±4	6±3	NA
		6/1	23	<4.8	4±3	NA
Cactus Springs:						
Mobil Service Station	13	4/7	27	<3.9	<3.3	<210
		6/1	27	<3.4	<3.4	<220
Caliente:						
Agricultural Extension Station	14	4/4	23	6±4	5±3	NA
		5/3	23	12±4.8	4±3	NA
		6/1	23	<4.5	6±3	NA
Meadow Valley Wash	15	4/4	22	<6.3	15±4.2	NA
		5/3	22	9±5	14±4.0	NA
		6/1	22	<5.5	18±4.1	NA
Clark Station:						
Five Mile Ranch	17	4/5	27	<3.2	10±4	NA
		5/3	27	<2.8	7±3	NA
		6/1	27	<4.7	5±4	NA
Coyote Summit:						
Sand Spring Well	18	4/5	23	33±9.9	18±4.3	NA
		6/1	23	21±9.4	25±4.7	NA
Currant:						
Currant Pond	19	4/6	21	7±5	11±3.9	NA
		5/5	21	10±4.9	5±3	NA
		6/1	21	<5.4	<3.2	NA
Currant Ranch Cafe	20	4/6	27	22±7.5	28±4.8	NA
		5/7	27	6±4	8±3	NA
		6/1	27	6±5	7±3	NA
Diablo Highway Maintenance Station	22	4/5	23	<3.2	10±3.8	NA
		5/4	23	<2.9	5±3	NA
		6/1	23	<4	9±4	NA
Diablo:						
Reed Ranch	23	4/5	21	29±8.3	8±4	NA
		5/3	21	29±9.1	42±5.2	NA
		6/2	21	20±8.7	43±5.5	NA
Elgin:						
Water Tower	24	4/5	23	21±8.5	11±4	NA
		5/4	23	10±5.3	13±3.9	NA
		6/1	23	7±5	13±3.7	NA
Ely:						
Chevron Service Station	25	4/4	24	<3.3	<3.4	NA
		5/3	24	<2.3	<3.1	NA
		6/1	24	<3.4	<3.4	NA
Comins Lake	26	4/4	21	11±1	29±6	NA
		5/3	21	11±6.2	38±5.1	NA
		6/1	21	8±6	47±5.5	NA
Eureka:						
Chevron Service Station	27	4/6	24	<3.8	<3.4	NA
		5/3	24	<2.6	4±3	NA
		6/1	24	6±5	9±4	NA
Glendale:						
Chevron Service Station	32	4/4	27	<6.0	9±4	NA
		5/5	27	8±5	17±4.2	NA
		6/2	27	<5.8	13±3.9	NA
Muddy River	33	4/4	22	<7.8	8±4	NA
		5/5	22	7±5	24±4.6	NA
		6/1	22	<7.5	21±4.4	NA
Goldfield:						
Alkali Springs	34	4/3	21	29±11	46±5.7	NA
		5/3	21	<8.5	32±5.1	NA
		6/1	21	<10	28±5.2	NA
Chevron Service Station	35	4/3	23	<4.0	<3.4	NA
		5/3	23	<3.9	4±3	NA
		6/1	23	<6.1	<3.5	NA
Hawthorne:						
Walker Lake [c]	36	6/1	21	<22	800±26	NA
Hiko:						
Crystal Springs	37	4/4	27	5±4	4±3	NA
		5/2	27	8±4	8±4	NA
		6/2	27	4±3	8±3	NA
Schofield Dairy	38	4/4	23	19±7.8	25±4.5	NA
		5/2	23	36±9.7	35±5.0	NA
		6/2	23	26±9.9	36±5.0	NA
Indian Springs:						
Chevron Service Station	40	4/6	23	<3.1	<3.1	<220
		5/5	23	6±4	<3.1	<220
		6/1	23	<4.3	4±3	<200
Las Vegas:						
Cal-Nev Jet Fuels	41	4/10	23	<4.4	6±3	<220
		5/8	23	4±3	6±3	<220
		6/1	23	<3.4	3±3	<210

See footnotes at end of table.

Table 2. NERC-LV water surveillance results, April-June 1972—continued

Location	Map number	Date collected (1972)	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada (continued)						
Craig Ranch Golf Course	42	4/10	23	8±4	5±3	<220
		5/8	23	7±4	5±3	<220
		6/1	23	5±4	5±3	<210
Cunningham Ranch	43	4/10	23	<2.9	<3.1	<220
		5/8	23	10±4	11±3.6	<220
		6/1	23	6±4	11±3.7	<210
Desert Game Range	44	4/7	23	6±4	7±3	<210
		5/5	23	7±4	5±3	<210
		6/1	23	<3.8	<3.4	<220
Desert Game Range Pond	45	4/7	21	<2.9	4±3	<220
		5/5	21	<3.7	4±3	NA
		6/1	21	<3.8	<3.4	<220
Francis Residence	46	4/10	23	<5.2	<3.2	<220
		5/8	23	6±5	<3.2	<220
		6/1	23	<5.8	<3.3	<210
Lab II, NERC-LV	47	4/10	24	<7.2	8±4	980±230
		5/8	24	9±6	12±3.8	1,100±210
		6/1	24	<6.0	11±3.8	1,000±220
Lake Mead Vegas Wash	48	4/10	21	<5.6	5±3	870±230
		5/9	21	<5.6	7±3	1,100±210
		6/1	21	<5.9	11±3.8	1,100±220
LDS Dairy Farm	49	4/11	23	<13	<4.0	<220
		5/9	23	<8.4	13±4.1	<200
		6/1	23	14±10	15±4.4	<210
Lloyd Ranch	50	4/10	23	11±7.9	4±3	<220
		5/8	23	7±6	9±4	<220
		6/1	23	<6.0	8±4	<210
L V Water District Well 28	51	4/10	23	<4.2	<3.3	<220
		5/8	23	13±4.9	5±3	<220
		6/1	23	<3.3	<3.2	<210
Municipal Golf Course	52	4/10	23	<4.3	<3.3	<210
		5/8	23	5±3	11±3.6	<220
		6/1	23	<3.3	5±3	<210
Tule Springs	53	4/7	23	<2.8	<3.1	<210
		5/5	23	4±3	4±3	<220
		6/1	23	<3.6	<3.4	<220
Tule Springs Pond	54	4/7	21	13±4.7	6±3	NA
		5/5	21	3±3	<3.1	NA
		6/1	21	<3.8	<3.4	NA
Vegas Estates	55	4/10	23	<8.2	8±4	<210
		5/8	23	<5.9	12±3.8	<220
		6/1	23	<6.6	12±3.9	<210
Lathrop Wells:						
Texaco Service Station	56	4/6	23	<4.1	4±3	<220
		5/2	23	<3.6	<3.2	<210
		6/1	23	<5.4	<3.5	<220
Lida Junction:						
Cottontail Ranch	57	4/3	23	5±4	15±4.1	NA
		5/5	23	<3.3	15±4.0	NA
		6/1	23	<4.2	15±4.0	NA
Lida:						
Lida Livestock Company	58	4/3	27	<2.9	<3.3	NA
		5/5	27	<3.6	8±3	NA
		6/1	27	<4.8	<3.4	NA
Pond at Storage Tank	59	4/3	21	14±5.8	6±4	NA
		5/5	21	<3.5	4±3	NA
		6/9	21	<4.5	<3.4	NA
Lund:						
Gardner Grocery	63	4/5	23	15±5.8	12±3.9	NA
		5/4	23	<2.7	<3.1	NA
		6/2	23	<4.1	5±3	NA
Manhattan:						
Country Store	64	4/5	23	19±7.3	6±4	NA
		5/4	23	20±7.7	5±3	NA
		6/2	23	13±7.7	12±4	NA
Seyler Reservoir	65	4/5	21	14±5.7	36±5	NA
Mercury:						
Groom Lake	66	4/4	23	<2.9	<3.3	NA
		5/2	23	<2.7	4±3	NA
		6/2	23	<5.1	4±3	NA
Moapa:						
Pedersen Valley View Ranch	67	4/4	27	<5.9	5±4	NA
		5/5	27	6±5	16±4	NA
		6/2	27	<6.8	10±4	NA
Mt. Charleston:						
Kyle Canyon Fire Station	68	5/5	27	<3.1	<3.1	280±220
		6/1	27	4±3	<3.1	<220
Kyle Canyon Pond	69	4/7	21	<2.7	<3.1	NA
		5/5	21	5±3	7±3	NA
		6/1	21	<3.3	11±3.6	NA
Nyala:						
Sharp's Ranch	72	4/5	23	<2.7	<3.3	NA
		5/3	23	<2.6	<3.1	NA
		6/1	23	<4.0	5±3	NA

See footnotes at end of table.

Table 2. NERC-LV water surveillance results, April-June 1972—continued

Location	Map number	Date collected (1972)	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada (continued)						
Pahrump:						
Texaco Service Station	74	4/10	23	<4.6	<3.3	<210
		5/3	23	<3.9	<3.2	NA
		6/2	23	4±3	<3.3	NA
Pioche:						
County Courthouse	75	4/5	24	<3.8	<3.4	NA
		5/3	24	<2.2	6±3	NA
		6/1	24	<3.5	6±3	NA
Round Mt:						
Mobile Service Station	77	4/5	27	14±5.0	<3.4	NA
		5/4	27	<3.1	5±3	NA
		6/2	27	<3.2	<3.4	NA
Scotty's Junction:						
Chevron Service Station	78	4/3	23	<4.7	9±4	<210
		5/5	23	6±5	13±4.0	<210
		6/1	23	<7	9±4	<220
Springdale:						
Peacock Ranch	80	4/12	27	<6.6	5±4	<210
		5/4	27	<4.3	8±3	<220
		6/2	27	<4.2	9±4	<220
Pond	81	4/12	21	<5.3	10±4	NA
		5/4	21	5±4	6±4	NA
		6/2	21	<6.6	10±3.9	NA
Sunnyside:						
Adam McGill Reservoir	83	4/5	21	8±5	4±3	NA
		5/4	21	7±4	7±3	NA
		6/2	21	<4.2	8±3	NA
Wildlife Management Headquarters	84	4/5	27	<3.4	<3.4	NA
		5/4	27	2±2	5±3	NA
		6/2	27	<3.9	<3.1	NA
Tonopah:						
Jerry's Chevron Station	85	4/4	23	4±3	13±3.9	NA
		5/4	23	6±4	7±3	NA
		6/1	23	<4.8	5±4	NA
Tonopah Test Range CP-1	86	4/4	23	10±6	10±4	NA
		5/3	23	<5.1	10±3.7	NA
		6/1	23	<5.6	6±4	NA
Warm Springs:						
Fallini's Pond	87	4/5	21	38±13	78±7.1	NA
		5/3	21	27±11	78±7.0	NA
		6/1	21	20±12	59±6.5	NA
Hot Creek Ranch	88	4/5	27	<4.8	9±4	NA
		5/3	27	<4.1	10±3.7	NA
		6/1	27	<7.5	9±4	NA
Service Station and Cafe	89	4/5	27	20±8.5	24±4.7	NA
		5/3	27	13±6.9	23±4.4	NA
		6/1	27	9±7	24±4.6	NA
Twin Springs Ranch	90	4/5	23	7±5	13±4.0	NA
		5/3	23	7±4	11±3.7	NA
		6/1	23	<5.7	10±3.9	NA
Utah:						
Cedar City:						
M. D. Baldwin Residence	16	4/5	24	<3.7	<3.4	NA
		5/3	24	2±2	<3.3	NA
		6/1	24	3±3	5±3	NA
Garrison:						
Pruess Reservoir [c]	30	6/2	21	11±6.5	15±3.9	NA
Rowley Grocery	31	4/4	23	6±4	9±4	NA
		5/8	23	5±4	6±3	NA
		6/2	23	<4.5	3±3	NA
Newcastle:						
Municipal Reservoir	70	4/5	21	21±7.1	20±4.4	NA
		5/3	21	9±4	11±3.8	NA
		6/1	21	10±5	10±4	NA
Newcastle Dairy	71	4/6	24	<5.4	<3.5	NA
		5/3	24	4±4	7±4	NA
		6/2	24	<5.1	8±4	NA
St. George:						
R. Cox Dairy	82	4/5	24	<2.6	<3.4	NA
		5/4	24	4±3	4±3	NA
		6/2	24	3±3	<3.1	NA

[a] Two-sigma counting error provided when available.
[b] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water, such as well and spring).
27—Spring.
[c] Quarterly samples.
NA, no analysis.
NS. no sample.

For the purpose of identifying the source of the gross radioactivity in all network samples and comparing sample concentrations with both AEC Concentration Guides and the PHS Drinking Water Standards, selected samples will be given special analyses at least once a year beginning with samples taken during calendar year 1972. For surface water samples, the special analyses will include strontium-89, strontium-90, plutonium-238, plutonium-239, uranium, and radium-226. For drinking water samples, the analyses will include strontium-89, strontium-90, uranium, and radium-226. The results of these special analyses will be reported at a later date.

Copies of these results are distributed to EPA Regional Offices and appropriate State agencies prior to publication.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Mexican air monitoring program	May-August 1972	January 1973
Plutonium in airborne particulates	April-June 1972	January 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January-December 1969	February 1972

1. Radiation Alert Network October 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 69 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during October 1972.

All other field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Precipitation			
								Field estimation of deposition		
			Maximum	Minimum	Average [a]		Total depth (mm)	Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	2	0	1	4	59	4	59	9
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	31	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	17	7	0	0	2				
Ark:	Little Rock	17	2	0	1	0				
Calif:	Berkeley	19	1	0	0	5	89	5	89	8
	Los Angeles	20	2	0	1	0				
C.Z:	Ancon	11	0	0	0	0				
Colo:	Denver	20	8	1	3	0		[b]		
Conn:	Hartford	19	2	0	0	6	49	6	49	0
Del:	Dover	18	1	0	0	0				
D.C:	Washington	22	2	0	0	0				
Fla:	Jacksonville	20	1	0	0	7	145	7	145	1
	Miami	0				0				
Ga:	Atlanta	12	2	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	20	1	0	0	3	54	[b]		
Idaho:	Boise	20	3	0	1	1	6	1	6	2
Ill:	Springfield	0				0				
Ind:	Indianapolis	19	1	0	0	0				
Iowa:	Iowa City	22	3	0	1	2	17	2	17	0
Kans:	Topeka	20	5	0	2	6	40	6	40	0
Ky:	Frankfort	14	2	0	1	0				
La:	New Orleans	21	1	0	0	3	159	[b]		
Maine:	Augusta	21	1	0	0	6	138	6	138	0
Md:	Baltimore	20	3	0	1	6	43	6	43	0
Mass:	Lawrence	20	2	0	0	3	71	3	71	0
	Winchester	20	3	0	1	6	86	6	86	0
Mich:	Lansing	21	2	0	0	5	65	5	65	9
Minn:	Minneapolis	20	2	0	1	6	72	6	72	10
Miss:	Jackson	15	2	0	1	3	72	3	72	0
Mo:	Jefferson City	20	5	0	1	3	22	3	22	0
Mont:	Helena	16	4	0	1	1	2	1	2	0
Nebr:	Lincoln	9	11	1	3	2	68	2	68	10
Nev:	Las Vegas	20	4	0	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	19	2	0	0	6	147	6	147	1
N. Mex:	Santa Fe	19	2	0	1	4	37	4	37	0
N.Y:	Albany	4	2	0	1	0				
	Buffalo	19	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	20	10	1	3	2	12	[b]		
N. Dak:	Bismarck	19	5	0	2	4	63	4	64	3
Ohio:	Cincinnati	0				0				
	Columbus	3	1	0	0	0				
	Painesville	22	1	0	0	7	76	7	76	17
Okla:	Oklahoma City	2	3	2	2	0				
	Ponca City	5	9	1	3	0				
Oreg:	Portland	21	1	0	0	4	28	4	28	4
Pa:	Harrisburg	18	3	0	1	0				
P.R:	San Juan	1	3	3	3	0				
R.I:	Providence	17	2	0	0	0				
S.C:	Columbia	13	6	0	1	3	41	3	41	0
S. Dak:	Pierre	20	9	1	3	0				
Tenn:	Nashville	16	2	0	1	8	109	8	109	0
Tex:	Austin	20	6	0	2	2	70	[b]		
	El Paso	22	5	0	2	0				
Utah:	Salt Lake City	27	3	0	1	7	95	7	95	17
Vt:	Barre	15	5	0	1	4	62	4	62	4
Va:	Richmond	16	1	0	0	1	54	1	54	10
Wash:	Seattle	9	0	0	0	2	11	[b]		
	Spokane	18	3	0	1	0				
W. Va:	Charleston	21	2	0	1	7	82	7	82	12
Wisc:	Madison	22	1	0	0	5	64	5	64	4
Wyo:	Cheyenne	16	8	0	3	0				
Network summary		1,010	11	0	1	144	76	5	66	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] October 1972

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for October 1972 are presented in table 2.

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	5	0.0	0.0	0.0	22	0.4
Coral Harbour	5	.0	.0	.0	14	.5
Edmonton	5	.0	.0	.0	70	.4
Ft. Churchill	5	.0	.0	.0	13	.4
Fredericton	5	.0	.0	.0	7	1.0
Goose Bay	5	.0	.0	.0	16	1.0
Halifax	5	.0	.0	.0	8	1.5
Inuvik	5	.0	.0	.0	30	1.2
Montreal	5	.0	.0	.0	8	.7
Moosonee	5	.0	.0	.0	NS	NS
Ottawa	5	.0	.0	.0	11	.9
Quebec	4	.0	.0	.0	30	3.9
Regina	5	.0	.0	.0	30	.3
Resolute	5	.0	.0	.0	29	.1
St. John's, Nfld.	4	.0	.0	.0	10	1.5
Saskatoon	5	.0	.0	.0	31	.3
Sault Ste. Marie	5	.0	.0	.0	18	.8
Thunder Bay	5	.0	.0	.0	6	.3
Toronto	5	.0	.0	.0	12	1.1
Vancouver	5	.0	.0	.0	14	.9
Whitehorse	5	.0	.0	.0	64	1.0
Windsor	NS				12	.8
Winnipeg	5	.0	.0	.0	17	.4
Yellowknife	3	.0	.0	.0	17	.6
Network summary	111	0.0	0.0	0.0	21	0.9

NS, no sample available.

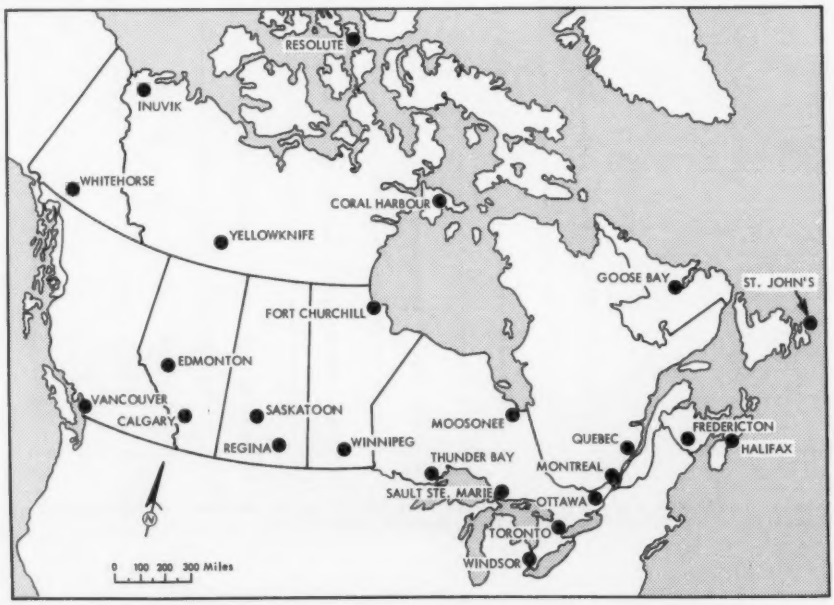

Figure 2. Canadian air and precipitation monitoring program

3. Pan American Air Sampling Program October 1972

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The locations of the air sampling stations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The October 1972 air monitoring results from the participating countries are given in table 3.

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, October 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	11	0.04	0.00	0.03
Chile:	Santiago	30	.13	.01	.04
Colombia:	Bogota	21	.02	.00	.01
Ecuador:	Cuenca	0			
	Guayaquil	13	.04	.01	.02
	Quito	16	.01	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	10	.01	.00	.00
West Indies:	Trinidad	8	.07	.01	.03
Pan American summary		109	0.13	0.00	0.02

[a] The monthly average is calculated by weighing the indivdual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging 0.00 pCi/m³.

4. California Air Sampling Program October 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Figure 4. California air sampling program stations

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for October 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air October 1972

Station location	Number of samples	Gross beta radioactivity [a] (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	31	0.85	0.01	0.13
Barstow	31	.70	.03	.18
Berkeley	29	.24	.01	.08
Colfax	19	.40	.00	.11
El Centro	29	1.14	.01	.16
Eureka	31	.18	.00	.06
Fresno	31	1.57	.03	.22
Los Angeles	31	.17	.03	.08
Redding	29	.32	.03	.09
Sacramento	31	.46	.00	.12
Salinas	31	1.39	.01	.28
San Bernardino	28	.85	.01	.16
San Diego	29	.47	.04	.12
Santa Rosa	31	.24	.01	.08
Summary	411	1.57	0.00	0.13

[a] Single sample taken at Orange, Calif., October 31, 1972, resulted in a gross beta activity of 0.07. This sample is not included in summary.

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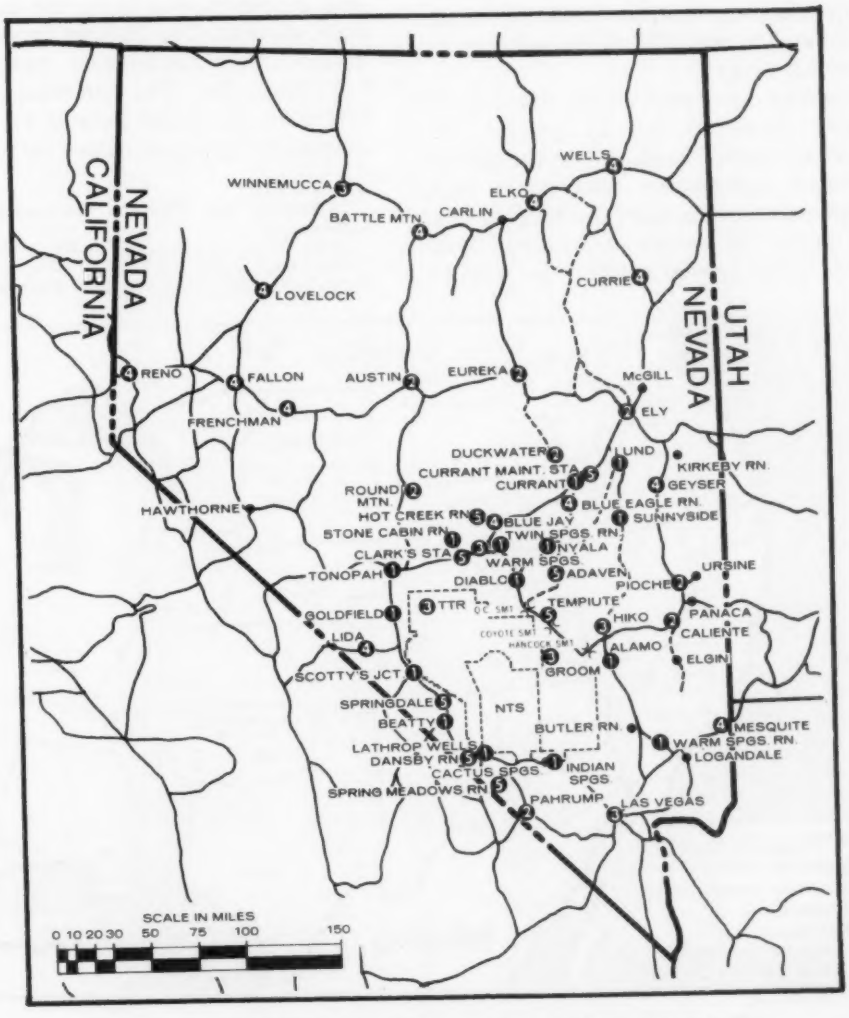

Figure 1. NERC-LV air surveillance network stations in Nevada

Air Surveillance Network, October 1972

National Environmental Research Center—Las Vegas,[1] Environmental Protection Agency

The Air Surveillance Network, operated by the National Environmental Research Center—Las Vegas, (NERC-LV), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station (which lies within the NTS), and by the AEC at any other designated testing sites.[2]

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta concentrations in air for each of the network stations. The highest gross beta concentration within the network was 0.5 pCi/m³ at Las Vegas, Nev. The minimum reporting concentration for gross beta is 0.1 pCi/m³. For averaging purposes, individual concentrations

[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

Figure 2. NERC-LV air surveillance network stations outside Nevada

Table 1. Summary of gross beta radioactivity concentrations in air October 1972

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average *
Ariz:	Kingman	31	0.4	<0.1	0.1
	Phoenix	29	.2	<.1	.1
	Seligman	31	<.1	<.1	.1
	Winslow	31	<.1	<.1	.1
Ark:	Little Rock	19	.1	<.1	.1
Calif:	Baker	31	<.1	<.1	.1
	Barstow	31	<.1	<.1	.1
	Berkeley	1	<.1	<.1	.1
	Bishop	31	<.1	<.1	.1
	Death Valley Junction	29	<.2	<.1	.1
	Furnace Creek	31	<.1	<.1	.1
	Indio	31	.2	<.1	.1
	Lone Pine	31	<.1	<.1	.1
	Needles	27	<.2	<.1	.1
	Ridgecrest	31	<.1	<.1	.1
	Shoshone	31	<.1	<.1	.1
Colo:	Denver	20	.1	<.1	.1
	Durango	6	<.1	<.1	.1
Idaho:	Boise	29	<.1	<.1	.1
	Idaho Falls	22	.1	<.1	.1
	Preston	30	.1	<.1	.1
	Twin Falls	31	.1	<.1	.1
Iowa:	Iowa City	20	<.1	<.1	.1
	Sioux City	25	.1	<.1	.1
Kans:	Dodge City	31	<.1	<.1	.1
La:	Lake Charles	21	<.1	<.1	.1
	Monroe	16	<.1	<.1	.1
	New Orleans	20	<.1	<.1	.1
Minn:	Minneapolis	20	<.1	<.1	.1
Mo:	Joplin	31	.1	<.1	.1
	St. Joseph	31	.1	<.1	.1
	St. Louis	31	<.1	<.1	.1
Nebr:	North Platte	25	<.1	<.1	.1
Nev:	Alamo	30	<.1	<.1	.1
	Austin	25	<.1	<.1	.1
	Battle Mountain	29	<.1	<.1	.1
	Beatty	31	<.2	<.1	.1
	Blue Eagle Ranch (Currant)	31	<.1	<.1	.1
	Blue Jay	31	.3	<.1	.1
	Caliente	29	<.1	<.1	.1
	Currant Ranch	31	<.1	<.1	.1
	Currie	30	<.1	<.1	.1
	Diablo	31	.4	<.1	.1
	Duckwater	26	<.1	<.1	.1
	Elko	31	<.1	<.1	.1
	Ely	30	<.1	<.1	.1
	Eureka	31	<.1	<.1	.1
	Fallini's Twin Springs Ranch	31	.1	<.1	.1
	Fallon	31	.2	<.1	.1
	Frenchman Station	31	.1	<.1	.1
	Geyser Maintenance Station	26	<.1	<.1	.1
	Goldfield	27	<.1	<.1	.1
	Groom Lake	31	.1	<.1	.1
	Hiko	30	<.1	<.1	.1
	Indian Springs	31	<.1	<.1	.1
	Las Vegas	21	.5	<.1	.1
	Lathrop Wells	29	<.1	<.1	.1
	Lida	31	<.1	<.1	.1
	Lovelock	31	<.1	<.1	.1
	Lund	32	<.4	<.1	.1
	Mesquite	31	<.1	<.1	.1
	Nyala	32	<.5	<.1	.1
	Pahrump	22	<.1	<.1	.1
	Pioche	31	<.1	<.1	.1
	Reno	31	.1	<.1	.1
	Round Mountain	31	<.1	<.1	.1
	Scotty's Junction	30	<.1	<.1	.1
	Stone Cabin Ranch	31	<.1	<.1	.1
	Sunnyside	28	<.1	<.1	.1
	Tonopah	31	.4	<.1	.1
	Tonopah Test Range	28	<.1	<.1	.1
	Warm Springs	2	<.1	<.1	.1
	Warm Springs Ranch	31	<.1	<.1	.1
	Wells	30	<.2	<.1	.1
	Winnemucca	30	<.1	<.1	.1
N. Mex:	Albuquerque	21	<.2	<.1	.1
	Carlsbad	30	<.1	<.1	.1
Okla:	Muskogee	31	<.2	<.1	.1
Oreg:	Burns	30	<.1	<.1	.1
	Medford	27	<.1	<.1	.1
S. Dak:	Aberdeen	31	<.1	<.1	.1
	Rapid City	26	<.1	<.1	.1
Tex:	Abilene	29	.2	<.1	.1
	Amarillo	31	.1	<.1	.1
	Austin	20	.1	<.1	.1
	Fort Worth	30	.1	<.1	.1

See footnote at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, October 1972—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average*
Utah:	Bryce Canyon	17	<.1	<.1	.1
	Cedar City	29	<.2	<.1	.1
	Delta	31	<.2	<.1	.1
	Dugway	31	<.1	<.1	.1
	Enterprise	31	<.1	<.1	.1
	Garrison	31	<.1	<.1	.1
	Logan	29	.1	<.1	.1
	Milford	31	.1	<.1	.1
	Monticello	31	<.1	<.1	.1
	Parowan	30	<.1	<.1	.1
	Provo	30	<.1	<.1	.1
	Roosevelt	31	<.1	<.1	.1
	Salt Lake City	30	<.1	<.1	.1
	St. George	31	<.1	<.1	.1
	Wendover	31	.1	<.1	.1
Wash:	Seattle	20	<.1	<.1	.1
	Spokane	18	.1	<.1	.1
Wyo:	Rock Springs	31	.2	<.1	.1
	Worland	31	<.1	<.1	.1

* Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reported value of 0.1 pCi/m³ is reported as <0.1.

which are below the minimum detectable concentration (0.06 pCi/m³) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level (0.1 pCi/m³) are reported as <0.1 pCi/m³. From gamma spectrometry results, 0.1 pCi/m³ of ruthenium-103 was identified on one filter collected on October 3, 1972, at Boise, Idaho. No other radionuclides were identified on any filters or charcoal cartridges during October 1972.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for the Brookhaven National Laboratory.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Brookhaven National Laboratory[2] July-December 1970

Associated Universities, Inc.
Upton, N.Y.

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by radioactivity in the cooling air from the research reactors (2) by radiation from an ecology forest gamma-ray source, and (3) by low-level radioactive liquid wastes released to a stream that forms one of the headwaters of the Peconic River (figure 1). The radiation levels resulting from reactor air effluent and the ecology forest source are monitored continuously by four stations located at the site boundary. The liquid

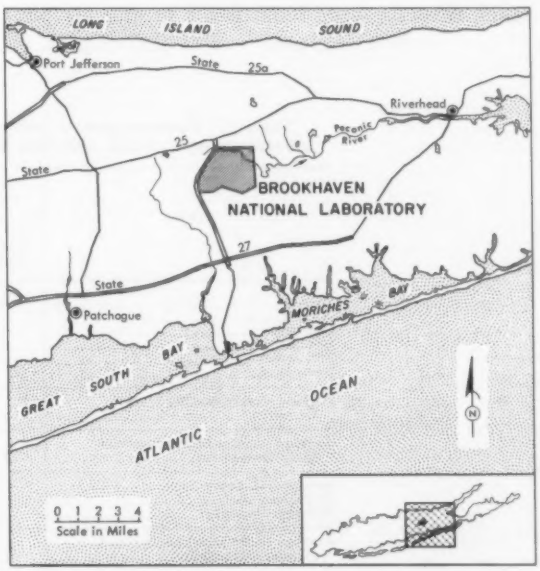

Figure 1. Brookhaven National Laboratory and surrounding area

[2] Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the First Half of 1970," Associated Universities Inc., Upton, N.Y. 11973.

waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the site.

Area monitoring

The average weekly radiation levels at the Brookhaven National Laboratory site perimeter (figure 2), due to laboratory operations, are given in table 1. Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to a cesium-137 source located in the nearby forest. The radiation levels at this location were only 3.5 percent of the established Atomic Energy Commission (AEC) radiation protection standard of 500 mrem/year for individuals in the general population. Values of radiation background levels undisturbed by laboratory operations also have been included in table 1 for purposes of comparison.

Air monitoring

No increments in air activity attributable to laboratory operations were detectable in the concentrations of gross beta radioactivity and no gamma-emitters attributable with laboratory stack releases were identifiable in any air particulate samples. The ambient background gross beta concentation was 0.17 pCi/m³. The applicable AEC standard is 100 pCi/m³. The radioiodine and tritium vapor concentrations were less than the lower limits of detection, which are 0.001 and 10 pCi/m³, respectively.

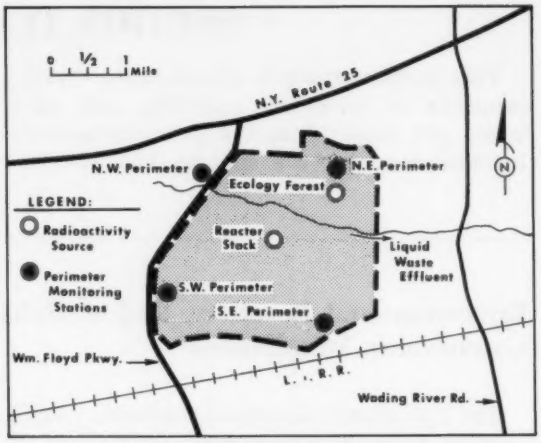

Figure 2. Brookhaven National Laboratory monitoring station locations

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the

Table 1. External gamma radioactivity at BNL site perimeter due to laboratory operations, July-December 1970 and annual summary 1970

1970	Average exposure rates (mR/week)			
	Northwest perimeter	Southwest perimeter	Southeast perimeter	Northeast perimeter [a]
July	0.00	0.00	0.00	0.38
August	.00	.00	.00	.38
September	.00	.00	.00	.34
October	.00	.00	.00	.35
November	.00	.00	.00	.33
December	.00	.00	.00	.30
Highest weekly reading (July–December)	0.00	0.00	0.00	0.40
Average undisturbed background (July–December)	2.00	2.01	1.83	1.79
Summary-January-June	.00	.00	.00	.29
July–December	.00	.00	.00	.35
January–December	.00	.00	.00	.32
Average undisturbed background (January–December)	1.77	1.89	1.73	1.78

[a] Levels measured continuously at station on former perimeter, 2,630 feet north of source have been adjusted on the basis of periodic measurements at the present perimeter, 3,405 feet north.

Table 2. Gross beta radioactivity in liquid waste effluent at BNL site boundary, July-December 1970

1970	Volume of flow (gallons/day)	Average beta radioactivity concentration (pCi/liter)	Total beta radioactivity concentration discharged (mCi)	Tritium concentration (nCi/liter)	Tritium radioactivity (Ci)
July	995,000	43	4.5	19	2.0
August	855,000	18	2.0	14	1.5
September	525,000	10	.6	8	.4
October	282,000	8	.3	18	.6
November	312,000	14	.6	4	.2
December	405,000	10	.5	7	.3
Summary:					
January–June	1,130,000	15	11.0	23	16.6
July–December	565,000	22	8.5	12	5.0
January–December	799,000	18	19.5	19	21.6

BNL site. The average concentation and total amount of gross beta radioactivity in the liquid waste effluent, at the site boundary, are shown in table 2 for July-December 1970.

Analysis of composite samples of the effluent has shown that, on the average, less than 20 percent of the radioactivity consists of strontium-90. No appreciable amounts of radioactive iodine or bone-seeking radionuclides (such as radium) other than strontium, were present. Under these conditions, the applicable AEC radiation protection standard for discharge of liquid waste to uncontrolled areas would be 1 nCi/liter averaged over a period of 1 year. The observed concentration in effluent was 2.2 percent of the standard.

Most gross beta measurement instruments are not sensitive to low energy beta emitters, such as tritium, for which special analytical methods must be employed. The concentration and amounts of tritium found during this reporting period in the laboratory's liquid waste effluent are also shown in table 2. The applicable AEC standard is 3 μCi/liter, averaged over a period of 1 year. The observed concentration of tritium at BNL was 0.4 percent of this standard.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-June 1970	December 1972

Reported Nuclear Detonations, January 1973

(Includes seismic signals presumably from foreign nuclear detonations)

There were no nuclear detonations or seismic signals reported by the U.S. Atomic Energy Commission for January 1973.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

CALCULATIONS OF ENVIRONMENTAL RADIATION EXPOSURES AND POPULATION DOSES DUE TO EFFLUENTS FROM A NUCLEAR FUEL REPROCESSING PLANT. *J. A. Martin, Jr. Radiation Data and Reports, Vol. 14,* February 1973, pp. 59–76.

Effluent and environmental data pertinent to the Nuclear Fuel Services nuclear fuel reprocessing plant in West Valley, N. Y., were analyzed to determine doses to sample populations. Individual doses to the maximally exposed population group were considered. Population doses (man-rems) from the air, fish, deer, and water pathways were calculated. The most significant radionuclides contributing to doses were tritium, krypton-85, strontium-90, cesium-134 and cesium-137. It was concluded that the impact of this facility upon humans was well below applicable guides in 1971.

KEYWORDS: Effluent, exposure, fuel reprocessing plant, krypton-85, New York, population doses, tritium

ASSESSMENT OF DOSES IN THE WESTERN UNITED STATES FROM THE PEOPLE'S REPUBLIC OF CHINA NUCLEAR TEST OF JANUARY 7, 1972. *R. B. Evans, R. N. Snelling, and F. N. Buck. Radiation Data and Reports, Vol. 14,* February 1973, pp. 77–83.

Measurable increases in airborne radioactivity were detected in the western United States by the Air Surveillance Network (operated by the National Environmental Research Center-Las Vegas, EPA) following a nuclear detonation by the People's Republic of China on January 7, 1972. The progress and intensity of the radioactive cloud across the United States is presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 1.2 mrem at Pueblo, Colorado.

KEYWORDS: Thyroid, iodine-131, nuclear detonation, tellurium-132, western United States, dose, airborne radioactivity

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